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WEST INDIAN AGRICULTURAL CONFERENCE, 1908.

(CONTINUED.)

In a previous number of the *West Indian Bulletin* a brief Abstract of the Proceedings of the Conference, held at Barbados from January 14-21, has been given. It is now proposed to publish in full the principal papers, together with summaries of the discussions upon each.

SUGAR INDUSTRY.

VARIETIES OF SUGAR-CANE AND MANURIAL EXPERIMENTS IN BRITISH GUIANA.

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OLDER VARIETIES OF SUGAR-CANE.

As I stated in the Paper prepared for the Conference held at Trinidad in 1905, we have practically discontinued experiments with the older varieties of sugar-cane other than Bourbon. We retain under experimental cultivation the Bourbon and the White Transparent, and these purely as standards for purposes of comparison.

. The White Transparent is the only one other than Bourbon of the older varieties which has been of late years

Many other varieties are also being cultivated on a large scale. The following are selected from the returns for the crops of 1907 :—

Variety.	Tons of sugar per acre.	Value per cent. compared with Bourbon.
Diamond 135	3·15	173·1
D. 4,101...	2·60	142·8
D. 130	2·30	140·2
D. 1,896...	1·95	131·7
Lahaina...	2·38	130·7
D. 4,415	2·34	128·5
B. 100	1·85	128·4
Green Transparent	1·81	122·2
D. 3,956	1·78	112·6
D. 3,287	1·75	112·2
B. 41	1·69	107·0
D. 115	1·62	106·3
D. 116	1·71	99·4
D. 2,468...	1·30	85·5

The following table shows the extension in areas under cultivation with the new varieties of sugar-canes which has taken place during the period under review :—

Variety.	1904-5.		1905-6.		1906-7.		1907-8.	
	No. of Plns.	Acreage.	No. of Plns.	Acreage.	No. of Plns.	Acreage.	No. of Plns.	Acreage.
D. 109 ...	32	5,491	34	8,386	39	1,184	36	9,849
D. 625 ...	27	1,445	34	3,357	34	5,600	36	9,662
B. 208 ...	8	1,437	15	2,125	18	3,189	23	5,258
D. 145 ...	27	1,316	26	1,842	28	2,403	28	3,282
B. 147 ...	21	1,329	21	1,733	24	1,963	19	1,652
White Transparent ...	30	1,796	23	1,416	19	1,043	14	637
Green Transparent ...	2	54	3	98	3	169	3	281
Lahaina ...	Not recorded		1	...	1	242	1	262
D. 116 ...	7	150	6	79	8	171	5	212
B. 109 ...	7	91	6	112	7	155	7	173
Diamond 185 ...	Not recorded		1	55	1	121	1	146
Sealy ...	12	221	11	220	10	226	3	111
D. 74 ...	11	157	7	118	5	98	3	93
D. 995 ...	10	231	6	170	6	153	3	53
D. 117 ...	5	21	6	88	6	55	5	51
D. 98 ...	11	277	7	179	5	107	4	34

In all 32,061 acres are occupied with new varieties of sugar-cane.

Our experience, as far as it goes, indicates that in the selection of seedling varieties more attention should be given to

the size of the cane, the number of shoots that each stool produces, and to its ratooning power, which is, in the majority of canes, dependent upon resistant power to disease and drought, than to its high saccharine contents. We have found that while the tendency is for decrease in the course of cultivation in the first-named qualities, the sugar contents, in many instances, tend in an opposite direction. Canes of exceptionally high sugar contents, in many cases, appear to be less resistent to adverse influences than those possessed of lesser sweetness. But this does not always hold good, a well-marked exception to it being B. 208. This cane, however, deteriorates to a very marked degree when grown on heavy clay soil having a strongly alkaline reaction.

We have among our later selection of seedlings, large-sized varieties of vigorously growing canes with high saccharine contents.

Perhaps the advantage of the new varieties which is most appreciated by the planters is that several kinds are capable of yielding large and remunerative crops of canes on land on which the Bourbon will not now thrive. Some varieties will flourish on the heavy clay front lands of the plantations; others on the somewhat lighter soils at the back of the cultivations. On some estates, the result of this is that the cane cultivation using new varieties is being extended at the back of the estates on soils that the Bourbon cannot flourish upon, while land set free from cane cultivation on the front lands is being planted with rice.

During the period under review, the area under Bourbon canes has decreased from 59,238 acres to 41,324 acres.

MANURIAL EXPERIMENTS.

Systematic manurial experiments have been carried on at British Guiana for nearly thirty years, and much information has accrued from them.

As was stated at the Conference of 1905, our experience is opposed to small-plot experiments carried out on estates, owing to the well-known causes of error inherent in them.

The soil on which we carry on our trials and the conditions which have governed them from their commencement in 1890 are described in the *West Indian Bulletin* (Vol. V, pp. 345-6). The weak point in these manurial experiments is that the land has not been cultivated with sugar-cane for a sufficient number of crops to bring into prominence its possible weakness in certain soil constituents, and hence in cases where negative results are recorded as attendant on application of certain constituents of manure, it is not at all certain that like results will follow similar applications on soils of plantations which have been under sugar cultivation for many years. Fortunately, simple analytical examinations of the soils will, as a rule, indicate whether or not they are likely to benefit from applications of these substances—potash, lime, and phosphates.

The consideration of the results will be here carried out on the same lines as it was in the 1905 paper.

Lime.—During the crops from 1892 to 1904 the increase per acre on unmanured land due to liming the land in 1891 with 5 tons of slaked lime per acre was 33·7 tons of sugar-cane, whilst on manured land it amounted to 37 tons. The increases since have been:—

Crop.	Tons of canes per acre.	
	Not manured.	Manured.
1905	(decrease 0·5)	1·7
1906	1·9	1·2
1907	1·6	(decrease 0·2)

Thus the total increase per acre recorded over the thirteen crops reaped (the crop of 1899 failed through drought) has been 36 tons of canes on unmanured land, and 39·7 tons on the manured land.

The mean increases of the plots were in 1905, 0·6, in 1906, 1·4, and in 1907, 0·4 tons of canes per acre respectively. It is evident from the many irregularities in the increased yields on the various plots which have been recorded during the last three crops that the beneficent action of the lime is approaching its period of exhaustion.

Phosphates.—We have nothing striking to record about the action of phosphatic dressings. In one series of experiments the mean annual results have been:—

		Tons of canes per crop per acre.	
		No phosphate.	Slag phosphate.
1902	Plant canes ..	68·6	68·0
1903	1st Ratoons ...	35·2	36·1
1904	2nd „ ...	21·5	22·3
1905	3rd „ ...	26·5	27·2
1906	4th „ ...	30·4	31·2
1907	5th „ ...	19·4	19·8
Mean of six crops, 1902-7.		33·6	34·1

In another series the records were :-

		Tons of canes per crop per acre.		
		No phosphate.	Slag phosphate.	Basic superphosphate.
1903	Plant canes ...	30·3	31·0	30·5
1904	1st Ratoons...	21·5	22·5	22·2
1905	2nd ,, .	21·1	21·6	21·4
1906	3rd ,, ...	25·5	25·0	25·9
1907	4th ,, ...	14·1	14·4	14·7
Mean of five crops, 1903-7.		22·5	22·9	23·0

Whilst in a third series on another field we obtained :—

		Tons of canes per crop per acre.	
		No phosphate.	Slag phosphate.
1903	Plants	23·5	24·1
1904	Ratoons ..	15·1	14·9
1905	Plants	16·4	16·7
1906	1st Ratoons ...	18·3	18·3
1907	2nd ,, ..	13·3	13·7
Mean of five crops, 1903-7...		17·3	17·5

The application of 6 cwt. of slag phosphate, costing approximately $6 00 in the first series of trials produced during six crops, 3 tons of canes nominally worth $6·00. Allowing 50c. per acre as the cost of application and charging 6 per cent. for the use of the capital expended in the purchase of the phosphates and for their application, the cost over the six crops amounts to $2·23 in excess of the value of the returns,

The application of the same weight of slag phosphates in the second series produced 2 tons of canes in five crops. The excess crops, therefore, cost $4·18 more to produce than they were worth. Where basic superphosphate was used, the produce was 2·5 tons in the five crops and the loss was $3·05 per acre.

In the third series, the slag phosphate produced 1 ton of canes in five years from the application of 6 cwt. of slag phosphate. Allowing for interest on the capital expended in the manuring, this trial resulted in a loss of $7·56 per acre.

As the first of these series of trials was on soil yielding ·007 per cent. of phosphoric acid (anhydride) in 1 per cent. solution of citric acid under conditions of constant shaking for five hours, the second was on soil yielding ·008 per cent., and the third on soil with an average content of ·013 per cent., the results fairly substantiate my statement made in 1903 to the effect that if a heavy clay sugar-cane soil in British Guiana shows on analysis a content of ·007 per cent. of phosphoric acid (anhydride) soluble in 1 per cent. citric acid solution under conditions of constant shaking for five hours, manurings with phosphates in all probability will not produce appreciably increased yields of sugar-cane.

My advice has been acted upon by several prominent planters who have submitted soils for the determination of whether they contain more or less than ·007 per cent. of phosphoric acid soluble in 1 per cent. citric acid solution.

The importation of slag phosphate into British Guiana has steadily diminished from 1,655 tons, valued at $21,849 at the port of shipment in 1902-3, to 287 tons valued similarly at $4,659 in 1906-7.

These trials have been made on soils which have well-marked alkaline reaction. On soils showing an acid reaction, phosphatic manurings may give increased yields of sugar-cane even if the soils yield as much as ·010 per cent. of phosphoric anhydride when treated with 1 per cent. citric acid solution.

Potash.—The soil of the experimental fields during the years 1891-1902 showed that they did not require applications of potash salts to ensure their maximum yields of sugar-cane, and hence trials of potassic manures have not been made on them since 1902. The soil contains 2·631 per cent. of total potash, of which ·596 is soluble in boiling hydrochloric acid, whilst ·0097 was in 1891 soluble in 1 per cent. citric acid. Cultivation during the years 1891 to 1902 increased the latter to ·0142 per cent. in soil on which potassic manures had not been used.

As our experience has shown that under the usual systems of cultivation in British Guiana a content of ·008 per cent. of potash soluble in 1 per cent. of citric acid can be regarded as supplying sufficient available potash for the needs of the sugar-cane, it was considered useless making further trials with potash salts on the experimental field. When analysis shows that the proportion of potash soluble in 1 per

cent. of citric acid has fallen to, or below, ·008 per cent., trials may be resumed.

Examinations of soils from plantations which have been cultivated with sugar-cane for many years have indicated that the contents of available potash of our experimental field is exceptionally high, and that there are soils in which the proportion of available potash is below ·008, and even in some cases below ·005. Where the proportion is between ·005 and ·008, it is advisable to make trial of light manurings, say of 60 to 100 ℔. of sulphate of potash to the acre; whilst where it is below ·005, manurings with potash salts should be regarded as an essential part of the treatment of the soil.

The results we have obtained in our trials with potassic manurings hence cannot be taken as guides for general agricultural practice in the colony, except in cases where the soils are known to be alkaline and to contain more than ·008 per cent. of potash which is soluble in 1 per cent. citric acid solution.

Nitrogen.—Although we have continued the trials with nitrogenous manurings with the Bourbon variety of sugar-cane our last series of experiments has not added much to our knowledge, that variety having been on our soils very susceptible to injury from drought and disease.

The series of comparisons of sulphate of ammonia and of nitrate of soda extended over twelve crops. The following results in mean increased yields given in tons of canes per acre per crop and as increase per cent. on the control plots which did not receive any nitrogenous manure have been obtained with manurings supplying 40 ℔. of nitrogen, but no cinereals, per acre per crop:—

Sulphate of ammonia.		Nitrate of soda.	
Increase in		Increase in	
Tons of canes.	Per cent. on no nitrogen.	Tons of canes.	Per cent on no nitrogen.
5·6	38·6	4·9	29·7

Manurings supplying nitrogen, with cinereals, in various quantities per acre per crop gave:—

Manurings of nitrogen in pounds per acre.	Sulphate of ammonia.		Nitrate of soda.	
	Increase in		Increase in	
	Tons of canes.	Per cent. on no nitrogen.	Tons of canes.	Per cent. on no nitrogen.
40	4·7	30·5	5·2	37·9
60	7·5	51·4	7·1	54·2
80	9·5	62·9	6·8	49·1

The increased yields given by heavy dressings of nitrate of soda during the later years of the comparison fell off so considerably from those obtained in earlier years that a new line of investigation, the details of which will be given later, was adopted.

These results obtained over twelve crops in fifteen years indicate that 10 lb. of nitrogen in the form of 50 lb. of sulphate of ammonia, when added in proportions up to 300 lb. per acre, give approximately 1·2 tons of canes or, say, at 9 per cent. recovery, $2\frac{1}{6}$ cwt. of commercial (96 per cent.) sugar. It is an easy matter to estimate, knowing the prices of sulphate of ammonia and of sugar respectively, if manurings on land in good heart with sulphate of ammonia are likely or not to prove profitable.

Similarly with nitrate of soda. In applications up to 250 lb. of nitrate of soda per acre, each 10 lb. of nitrogen will probably give 1·3 tons of canes or nearly $2\frac{1}{2}$ cwt. of commercial (96 per cent.) sugar. But as a rule it is not advisable to apply more than 250 lb. of nitrate of soda per acre at one dressing.

In considering the results obtained with varieties other than Bourbon, it will, I think, suffice for our present purpose to consider the mean results obtained with high and low nitrogenous dressings, the high ones being applications averaging 80 lb. of nitrogen per acre, the low ones averaging 40 lb.

(1) *D. 625.* For the six crops of 1901-7, the results have been :—

	Tons per acre per crop.	Per cent. increase on no nitrogen
No nitrogen	31·0	
Low „	37·1	19·7
High „	41·0	32·2

This variety is one of exceeding vigour and is capable of utilizing soil-nitrogen to a marked degree. Where sulphate of ammonia has been applied in dressings of less than 300 lb. per acre, 40 lb. of nitrogen have produced a mean increase of 1·5 tons of canes per acre, whilst where it has been applied in excess of 300 lb., each 10 lb. of nitrogen applied has produced 1·2 tons of canes. Or whilst the mean effects of each of the first four 10 lb. of nitrogen applied have been 1·5 tons of canes per acre, the mean effects of each of the next four 10 lb. of nitrogen were about 1 ton.

(2) *B. 208.* This well-known variety does not flourish on the heavy clay soils of the experimental field. Its records during two crops (1905-7) have been as follows :—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen	13·5	—
Low "	15·3	13·4
High "	21·6	60·0

This variety appears on the soil of the experimental field to require and to utilize heavy dressings of nitrogen. It has not been long enough under experiment to draw any other deductions as to its demand for manurial nitrogen.

(3) *D. 145.* For the seven crops of 1900-7 the results for this variety have been as follows :—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen	22·6	—
Low "	29·4	30·1
High "	33·3	47·3

With D. 145 each 10 lb. of nitrogen when applied in proportions less than those contained in 300 lb. of sulphate of ammonia produced a mean yield of 1·7 tons of canes, whilst where applied in excess each 10 lb. produced a mean yield of 1·33 tons of canes. Or whilst the effects of each of the first

four 10 lb. have been 1·7 tons of canes, the mean effects of each of the next four 10 lb. were only about 1 ton.

(4) *D. 95.* This variety has only been examined as to its requirements for nitrogen with low dressings. Its results have been :—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen	28·6	—
Low "	31·8	11·2

Its short period of growth apparently prevents it making full use of nitrogenous manurings, 10 lb. of nitrogen producing only 0·8 ton of canes.

(5) *Sealy.* This kind has been under manurial trial during two crops only and its record is :—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen	18·8	—
Low "	25·1	33·5
High "	26·8	42·5

The Sealy has not been under trial long enough to enable us to draw any definite conclusions from its yields.

(6) *D. 109.* This has been under trial since 1900 and its mean record for seven crops (1900-7) is as follows :—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen	23·6	—
Low "	27·2	15·2
High "	33·3	41·1

This variety requires heavy dressings of nitrogen, and responds well to manurings. Each 10 ℔. of nitrogen when applied in heavy dressings has produced a mean yield of 1·2 tons of canes.

(7) *B. 147.* This has been experimented with during five crops (1902-7) with the following mean results:—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen	20·8	—
Low ,,	26·7	28·5
High ,,	30·6	47·1

The effects of nitrogenous manurings in producing increased yields of canes are very similar to those with D. 625.

(8) *D. 74.* This kind has been tried in a similar manner to D. 95 and for four crops (1901-5) only. Its record is:—

	Tons per acre per crop.	Per cent. increase on no nitrogen
No nitrogen	26·9	—
Low ,,	36·2	34·6

This variety, although one of relatively short period of growth, gives exceptionally high returns in response to nitrogenous dressings, each 10 ℔. of nitrogen having produced 2·3 tons of canes.

(9) *White Transparent.* The results with this variety have been:—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen	18·9	—
Low ,,	24·6	30·2
High ,,	27·8	47·1

This variety responds more fully to low dressings of nitrogen than to high ones.

(10) *D. 78.* The experimental cultivation of this variety was abandoned in 1905 owing to the highly unsatisfactory mode of growth it had assumed after several years' cultivation. Its record for 1900-4 was :—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen	21·1	—
Low „	28·2	25·1
High „	33·6	59·2

(11) *D. 116.* The records for six crops (1901-7) are as follows :—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen	29·0	—
Low „	33·5	15·5
High „	38·2	31·7

Each 10 lb. of nitrogen with this variety has produced 1·15 tons of canes.

(12) *D. 3,956.* The record of this promising variety for six crops (1901-7) is :—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen	29·4	—
Low „	35·0	19·0
High „	39·7	35·0

With D. 3,956, each 10 lb. of nitrogen has produced 1·3 tons of canes.

(13) *D. 115.* This variety has only been under experiment for four crops from 1901-5, with the following results:—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen ...	25·4	—
Low „ ...	32·5	22·8

This variety gave 1·8 tons of canes for each 10 lb. of nitrogen applied to it in manures.

(14) *D. 130.* This has been experimented with on similar lines to D. 74 and D. 95 for four crops (1901-5) only. Its record is :

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen ...	33·1	
Low „ ...	41·7	26·0

D. 130 gave 2·15 tons of canes for each 10 lb. of nitrogen applied to it as manure.

(15) *D. 2,190.* Owing to its unsatisfactory mode of growth, this variety was tried for three crops (1903-5) only. Its results were :—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen ...	17·9	—
Low „ ...	21·1	17·9
High „ ...	28·0	56·4

It required heavy dressings of nitrogenous manure to produce fair crops.

(16) *D. 1,087.* Only tried during the three crops of 1905-7. Its record is :—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen ...	14·9	—
Low „ ...	20·7	39·9
High „ ...	30·4	104·0

With this variety, 10 lb. of nitrogen have resulted in 1·9 tons of canes. It evidently requires heavy dressings of manure to produce satisfactory crops.

(17) *D. 4,397.* Only experimented with in 1906 and 1907. Its results are :—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen ...	20·0	—
Low „ ...	26·5	32·5
High „ ...	31·9	59·5

(18) *D. 2,468.* This variety was on trial during the crops of 1905-7, with the following results :—

	Tons per acre per crop.	Per cent. increase on no nitrogen.
No nitrogen ...	10·9	—
Low „ ...	18·0	65·1
High „ ...	23·0	111·0

A variety requiring high manuring to produce satisfactory crops. With moderate dressings of nitrogenous manure, 10 lb. of nitrogen produced 1·8 tons of canes.

These trials, I think, fully bear out my statement made in 1905, that every one of our new varieties requires manuring

with nitrogen to give really satisfactory results; that some of the varieties have higher power of utilizing soil nitrogen than the Bourbon has; and that, while certain of them appear not to utilize manurings with nitrogen to as great advantage as does the Bourbon, others, on the contrary, utilize them to greater advantage.

There has been, and still is, very great difficulty in collating the results given by new varieties of plants, when cultivated experimentally on small plots, with those obtainable on the large scale. And this refers not only to the actual yields of a variety, but to its yields as compared with those of other kinds. It is of course everywhere received as proved that the yields on small scale and plot experiments are, as a rule, far higher than those obtained in practical agriculture, and this must so remain until a time arrives, if ever it will, when it is possible to give to extensive cultivation the same minute care which is lavished on intensive small scale and plot experiments.

My experience is that by growing varieties of sugar-cane under several different systems of manuring, as I have done in the experiments with regard to the manurial requirements of the newer varieties of sugar-cane, and by taking the means of the results produced by a variety with the different manures applied to it, more reliable indications of the probable relative values of varieties when cultivated on large scales are obtainable than where the results of cultivation with one system of manuring only are considered. Thus in the more complete of our experiments we have raised the varieties with twelve variants:

1. Without manure.
2. With slag phosphates only.
3. With nitrogen only, in various quantities, as under:—

   (a) 20 lb. nitrogen.
   (b) 40 „ „
   (c) 60 „ „
   (d) 80 „ „
   (e) 100 „ „

4. With slag phosphates and nitrogen, in various quantities, as under:—

   (a) 20 lb. nitrogen.
   (b) 40 „ „
   (c) 60 „ „
   (d) 80 „ „
   (e) 100 „ „

The mean results thus obtained from our plot experiments, and the means of the results reported to the Sugar-cane Experiments Committee of British Guiana as obtained on sugar-estates compare as follows:—

	Plot experiments.	Estate returns.
	Tons of saccharose in juice per acre.	Tons of commercial sugar per acre.
D. 625	4·75	2·26
D. 145	4·48	1·93
D. 95	3·80	1·83
D. 109	3·66	1·80
B. 147	2·76	1·75
Bourbon ...	2·48	1·74
D. 74	3·72	1·69
White Transparent... ...	2·88	1·54

Here with the exception of the relative positions of D. 74 and of the White Transparent, there is a general concordance in the order of the relative values of the canes as deduced from the small-plot experiments and as found on sugar-estates in the colony.

THE EFFECTS OF LONG-CONTINUED APPLICATIONS OF SULPHATE OF AMMONIA AND OF NITRATE OF SODA ON THE PRODUCTIVENESS OF THE SOIL.

As before mentioned, during the third series of experiments with Bourbon canes (1900-4), the crops on the plots which had been highly manured with nitrate of soda showed well-marked signs of decrease in their yields as compared with those which had been highly manured with sulphate of ammonia. Thus during the first and second series the excesses on the yields of the not-manured plots produced by manurings of 400 lb. of sulphate of ammonia and of 500 lb. of nitrate of soda were 7·5 and 6 tons respectively, or 25 per cent. in favour of the sulphate of ammonia; whilst during the third series the excess yields were 16·1 and 11·2 tons, or 43·7 per cent. higher in the case of the sulphate of ammonia than in that of the nitrate of soda.

When the plots were replanted for the crop of 1905 they were manured with sulphate of ammonia, and it was found that the increase due to manurings averaging 300 lb. of sulphate of ammonia per acre was 8·9 tons of canes per acre where sulphate of ammonia had been previously used, against 7·4 tons per acre where nitrate of soda had been applied. The increases were therefore 20 per cent. higher on the land which had been

manured with sulphate of ammonia for many years than on that which had been similarly dressed with nitrate of soda. (It was intended to have manured six plots with nitrate of soda, but at the time of application of the manures none of this substance was obtainable in British Guiana.)

During the growth of the 1904-5 crop, representations were made to me by persons interested in the sugar industry of the colony to the effect that the marked falling-off which had been noticeable of late years in the productive power of some of the cane-fields might be due to the effects of long-continued, repeated manurings with sulphate of ammonia, and was thus similar to what had occurred at the Woburn Experimental Farm of the Royal Agricultural Society, England, and to a less extent on certain of the Experimental Fields at Rothamsted. The soil of the former place is a light sandy one, but that of the latter is a clay loam. Where sulphate of ammonia has been used continuously at Woburn for between twenty and thirty years, the soil has been rendered absolutely barren for economic plants, whilst the evil effects of the long-continued manurings (for fifty years and over) at Rothamsted with the same salt are now very perceptible.

Advantage was therefore taken in 1905 of the mode in which the experiments have been conducted, to arrange trial plots for examining into the question whether the use of sulphate of ammonia from 1892 to 1905 had been injurious to the soil of the experimental field, and whether better results would not be obtained by the substitution of nitrate of soda for sulphate of ammonia.

The previous manuring of the field allowed the following comparisons to be made with three varieties of canes on not-limed and on limed land :—

Sulphate of ammonia after sulphate of ammonia (fourteen years)
Sulphate of ammonia after nitrate of soda „ „
Nitrate of soda after sulphate of ammonia „ „
Nitrate of soda after nitrate of soda „ „

The following were the mean results in tons of canes per acre during the crops of 1906 and 1907 :—

	1906.	*1907.*	*Means.*
No nitrogen	11·5	5·2	8·35
Sulphate of Ammonia			
After sulphate of ammonia	23·5	19·4	21·45
After nitrate of soda	19·2	15·1	17·15
Nitrate of Soda			
After sulphate of ammonia	20·7	8·8	14·75
After nitrate of soda	18·9	9·2	14·05

The weather during 1907 was singularly unfavourable for obtaining satisfactory returns from nitrate of soda owing to the continuous heavy rains which occurred during some months after its application.

These trials showed a mean increase of 9·75 tons of canes per acre by nitrogenous manuring on soil long manured with sulphate of ammonia, as compared with 7·25 tons on that which had been similarly manured with nitrate of soda—an increase of 34·5 per cent. in favour of the sulphate of ammonia soil.

The substitution of nitrate of soda for sulphate of ammonia resulted in the increase being lowered from 13·1 tons of canes per acre to 6·4 tons. Much of this decrease, however, was due to the unfavourable meteorological conditions adversely affecting the nitrate of soda. The substitution of sulphate of ammonia for nitrate of soda on the plots long manured with the latter was attended by a mean increase of 3·1 tons of canes per acre.

The results obtained during the third series of experiments and during the three crops of 1905, 1906, and 1907 point to peculiarities in the soil which, whilst preventing any injurious action of the long-continued application of sulphate of ammonia, had caused those of nitrate of soda to act detrimentally on it. In my opinion they indicate that in very heavy clay soils, such as those of the experimental fields, and under tropical meteorological conditions, the deflocculation or puddling caused by long-continued dressing with nitrate of soda is likely to prove more injurious to the productive power of the soil than is the souring action, either direct or indirect, of sulphate of ammonia.

The fact that during our first series of experiments (crops of 1892-6) the increase produced by each 10 lb. of nitrogen, where manurings of 400 lb. of sulphate of ammonia (=80 lb. nitrogen) per acre were used, was 1·21 tons of sugar-cane, whilst in our third series it was 2·01 tons, tend to show that the long-continued applications of sulphate of ammonia, instead of injuring the productive power of the soil have rather improved it.

In 1902-3, a series of determinations of the nitrogen and of the manurial constituents of plant food of ready availability as measured by their solubility in $\frac{1}{200}$ per cent. hydrochloric acid was made on this soil. The mean results were as follows :—

	Soil in 1891.	Soils in 1902-3.		
		No nitrogen, 1891-1902.	Sulphate of ammonia, 1891-1902.	Nitrate of soda, 1891-1902
Nitrogen	·177	·137	·148	·139
Potash	·0104	·0265	·0172	·0174
Lime	·127	·159	·169	·167
Phosphoric acid	·0019	·0021	·0020	·0018

Careful study of these figures gave little, if any, assistance towards the solution of the problem.

It was therefore evident, that the changes which had taken place in the soil were not likely to be recognized by ordinary methods of chemical analysis.

It appeared to me that these could only be ascertained by utilizing some process, natural or artificial, by which the results of the changes taking place in very large quantities of the soil and over prolonged periods, would be accumulated and concentrated.

These heavy clay soils are only surface-drained. Subsoil drainage has been tried on similar soils in British Guiana on a large scale on several occasions and has invariably failed, owing to the great retentive power of the lower layers of the soil. For example, it was tried for many years on about 20 to 30 acres of the Botanic Gardens, where it was a complete failure.

Water which slowly percolates through the upper layers of the soil accumulates at and below the level of the water-table. Where the water-table is near the surface, during each prolonged dry season, some of this water is brought up by capillary action into the upper and cultivated parts of the soil and is there subject to concentration by evaporation. At the commencement of the rainy season this concentrated water is driven down in advance of the slowly percolating rain-water—in a manner well known to every soil analyst—and thus the soil-water tends to become more and more concentrated at the level of the water-table. It appeared to me that examinations of this naturally concentrated soil-solution would possibly assist in the elucidation of the problem.

During the dry season of 1907, I caused holes to be dug in several places in the experimental fields. It was found that at depths of from 4 to 5 feet the soil was saturated with water, and at the level of the water-table, when the holes were sunk

a few inches lower, water gradually accumulated in them. As a general rule, in from twelve to twenty-four hours we were able to collect from about ½ to 1 gallon of soil-water from each of the holes.

The first holes put down were in the rice field, and preliminary examinations showed that the soil-water was markedly alkaline.

The following is a list of the holes sunk from which water was obtained for examination :—

Places.	No. of Holes.
Rice field, part not cultivated, until recently a bush-covered swamp	2
Rice field, irrigated, 1903-7	2
Botanic Gardens, very heavily manured with stable manure, 1880-1907	1
Botanic Gardens, repeatedly gypsumed in 1886-9 and heavily manured with stable manure	1
Brickdam field, uncultivated paths	2
Old cane field, uncultivated paths	3
,, ,, ,, not-limed plots, not manured	3
,, ,, ,, limed plots, not manured	3
,, ,, ,, not-limed plots, sulphate of ammonia, 1892-1907	3
,, ,, ,, limed plots, 1892-1907	3
,, ,, ,, not-limed plots, nitrate of soda, 1892-1907	6
,, ,, ,, limed plots nitrate of soda, 1892-1907	6
New cane field, uncultivated paths	5
,, ,, ,, not manured plots	6
,, ,, ,, plots manured with sulphate of ammonia, 1901-7	6

Determinations of the more important constituents were separately made in each of these samples, and the means were taken as representing the nature of the soil-water characterizing the soils under their conditions of cultivation. A general agreement in composition was found to exist in the samples from the various similarly treated paths and plots, but as was expected, differences in the degree of concentration of the soil-waters were more or less marked. For the determination of the general composition of the soil-waters, composite samples were made by mixing equal proportions of the waters from the holes in similarly treated places and these—eighteen in number—were submitted to more exhaustive examinations.

The analytical examinations were made by well-known methods of which it is unnecessary to detail here. The temporary and permanent alkalinity were determined by using methyl orange as the indicator.

As it is impossible in our present state of knowledge to state how the various constituents of the water, if combined together, are combined, the results are here given in the simplest form, the proportion of the various ions contained in 1,000,000 parts of the soil-water (milligrammes per litre). The following table shows them :—

EXPERIMENTAL FIELDS AND NURSERY, BOTANIC GARDENS.

SOIL-WATERS—PARTS PER 1,000,000.

SAMPLE.	Chlorine. Cl.	Sulphate ion. SO_4.	Carbonate ion. CO_3.	Iron. Fe.	Calcium. Ca.	Magnesium. Mg.	Potassium. K.	Sodium Na.	Nitrate ion. NO_3.	Ammonium. NH_4.	Total Nitrogen. N.	Alkalinity. Temporary as calcium carbonate.	Alkalinity. Permanent as sodium carbonate.
Nursery.													
Eastern beds	3,560	1,080	511	62	233	288	16	2,345	0·460	0·393	0·414	314	450
Northern beds, gypsumed ...	2,640	1,092	349	traces	199	272	72	1,700	0·795	1·051	1·008	467	120
Brickdam Field.													
Uncultivated paths	6,050	1,716	470	—	292	242	30	4,264	1·949	0·007	0·447	357	450
Rice Field.													
Land not irrigated	7,700	1,428	542	66	114	894	46	4,244	0·038	0·019	0·027	54	383
Irrigated rice beds	2,400	792	416	—	120	260	30	1,677	0·366	0·381	0·443	328	386
Old Cane Field.													
Uncultivated paths	4,210	612	574	—	192	300	108	2,619	1·236	0·007	0·286	457	528
Plots, not limed or manured	3,290	648	467	—	200	328	78	1,877	1·742	0·011	0·403	357	446
,, limed	3,180	564	524	—	267	312	50	1,610	1·743	0·007	0·400	308	597

EXPERIMENTAL FIELDS AND NURSERY, BOTANIC GARDENS.—(*Concluded.*)

SOIL-WATERS—PARTS PER 1,000,000.

SAMPLE.	Chlorine. Cl.	Sulphate ion. SO_4.	Carbonate ion. CO_3.	Iron. Fe.	Calcium. Ca.	Magnesium. Mg.	Potassium. K.	Sodium. Na.	Nitrate ion. NO_3.	Ammonium. NH_4.	Total Nitrogen N.	Alkalinity. Temporary as calcium carbonate.	Alkalinity. Permanent as sodium carbonate.
Old Cane Field. (*Concluded.*)													
Plots, not limed, manured with sulphate of ammonia	3,390	636	533	—	445	195	40	2,048	1·312	nil	0·297	386	53
Plots, limed „ „ „ ...	2,480	480	498	—	295	190	32	1,532	1·251	nil	0·283	246	617
„ not limed, manured with nitrate of soda ...	3,420	468	670	81	319	292	21	1,951	1·190	nil	0·270	280	707
„ limed „ „ „ ...	3,190	792	544	—	233	198	21	2,084	1·976	nil	0·447	285	669
New Cane Field.													
Western uncultivated paths	3,390	1,148	359	—	192	306	28	2,248	0·533	nil	0·121	414	194
Eastern „ „	3,230	648	521	—	478	264	31	1,888	1·338	nil	0·303	448	443
Plots, not manured 8′	3,600	648	547	46	190	404	84	2,040	1·313	nil	0·297	386	468
„ „ „ 4′	3,520	600	498	31	219	390	17	1,951	0·144	0·375	0·328	386	410
„ sulphate of ammonia 8′	3,260	720	457	15	125	352	55	1,973	1·540	nil	0·348	348	407
„ „ „ „ 4′	3,260	480	495	—	242	348	36	1,810	0·038	0·834	0·666	357	493

The chlorine and bromine and parts, at any rate, of the other constituents have been derived from sea-water, either directly or indirectly. They in part may have been in solution in the brackish water which at one time covered the present surface, but in part they must have been derived from the sea-salts which are carried from the ocean in spray by the wind and are brought down to the land in solution in rain-water.

The first question for decision is—Have these salts been solely derived from sea-water? The following comparisons, in which the various ions present in the soil-water from the uncultivated and cultivated land in proportion to their contents of chlorine taken as 100, and compared with the ions of sea-water similarly shown, will decide this:—

	Soil-water from		Sea-water.
	Uncultivated soil. Mean of four composite samples	Cultivated soil. Mean of twelve composite samples.	
Chlorine	100·00	100·00	100·00
Bromine*	·06	·06	·34
Sulphate ion (SO_4) ...	24·44	22·66	13·82
Carbonate ion (CO_3) ...	11·37	15·93	·37
Iron	...	·58	...
Calcium	6·00	8·16	2·16
Magnesium	6·59	9·06	6·74
Potassium	1·16	1·42	2·00
Sodium	65·18	60·05	55·33
Total	214·80	217·92	180·76

* Determined in a composite sample, measuring 8 litres, of the soil-waters.

For every 100 parts of chlorine in the sea-water from which the ions were derived, the soil-waters from not-cultivated land show an excess of 10·62 of the sulphate ion, of 11·00 of the carbonate ion, of 3·84 of calcium, and 9·85 of sodium, with a deficit of 0·28 of bromine, 0·15 of magnesium, and 0·84 of potassium. The soil-waters from cultivated land show an increase of 8·84 of the sulphate ion, 15·56 of the carbonate ion, 0·58 of iron, 6·00 of calcium, 2·32 of magnesium,

and 4·69 of sodium, with a deficit of 0·28 of bromine, and 0·58 of potassium. Hence it is clear that the soil-waters are materially different in their contents of dissolved ions from diluted sea-water.

This shows generally, that there is a considerable excess of sulphates and carbonates and of calcium and magnesium in the soil-waters over those present in sea-water : whilst the soil-waters from cultivated land show a marked increase in the proportions of carbonates over those of the water from the not cultivated land.

If it is assumed that the ions in the soil-waters are combined together in the manner frequently adopted in statements of analyses of water, the soil-waters would have to be considered as solutions of the bicarbonates of calcium and magnesium in water containing also in solution magnesium sulphate, magnesium chloride, and sodium chloride ; the relative proportions of carbonates in the water from the not-cultivated and the cultivated soils being in round figures as 10 to 14. When the bicarbonates are dissociated and the excess of carbonic acid is driven off, we should expect the waters to be practically neutral in reaction, or rather somewhat alkaline, but only to the extent to which calcium and magnesium carbonates are soluble in saline water of this character. But on such dissociation a far more complicated change takes place. The alkalinity of the soil-water is equivalent to 19·9 parts of calcium carbonate per 100 parts of chlorine in the waters from the not-cultivated soils, whilst in those from the cultivated soils it is 25·9. But when the waters are carefully boiled so as to drive off the carbonic acid without allowing concentration by loss of water to take place, the alkalinity is only reduced to the equivalent of 10·0 and 15·1 parts of carbonate of calcium respectively.

The composition of the precipitated carbonates was determined in several cases, and they were found to consist of calcium and magnesium carbonates in approximately molecular proportions. The residual water was in every case markedly alkaline.

This is in accordance with the results obtained by others when working on saline waters of complex composition. The solids contained in solution in the water do not split up on either rapid or slow evaporation simply into insoluble carbonates and soluble alkaline salts, but certain proportions of the calcium and magnesium present are deposited as carbonates, whilst the rest of the solids remain as salts in solution. The calcium apparently remains as sulphate, and as chloride; the magnesium as sulphate, chloride, and carbonate, whilst the sodium and potassium appear to be present in part as sulphates, in part as chlorides, and in part as carbonates.

That this is essentially what takes place during the gradual evaporation of the soil-waters we have proved by several experiments ; and it is, in my opinion, to the production of carbonate of soda and of the soluble double carbonate of magnesium and sodium that the injurious effects on plants of the concentrated soil-waters are largely due. We examined

eighty-seven samples of soils from various parts of the colony which were taken during the dry season from fields the soil-water of which were more or less alkaline, and we found that the watery extracts from these soils were all alkaline to litmus paper, and we proved that the alkalinity was due to the presence of sodium carbonate and of the soluble double carbonate of magnesium and sodium. Thirty-eight of the soil-extracts were markedly alkaline, thirty-three alkaline, whilst sixteen were only slightly alkaline.

THE EFFECTS OF CULTIVATION AND OF MANURES ON THE COMPOSITION OF THE SOIL-WATERS OF THE SUGAR-CANE EXPERIMENT FIELDS.

The mean results of the examinations of the soil-waters from the plots on the long-cultivated manurial experimental field (South Field) which has been in sugar-cane since 1891 next require consideration. Reduced to a basis of 100 parts of chlorine, they are as follows:—

	Not cultivated.	Cultivated, not manured.	Cultivated, manured with	
			Sulphate of ammonia.	Nitrate of soda.
Chlorine	100·0	100·0	100·0	100·0
Sulphate ion (SO_4) ...	14·5	18·6	19·6	19·2
Carbonate ion (CO_3) ...	13·6	15·5	17·7	18·0
Iron	—	—	—	1·1
Calcium	4·6	7·2	12·4	9·8
Magnesium	7·1	10·4	5·8	7·0
Potassium	2·6	2·0	1·2	0·6
Sodium	62·2	53·7	60·7	60·8
Total	**204·6**	**207·4**	**216·8**	**216·5**
Temporary alkalinity ...	**10·8**	**10·3**	**10·7**	**8·6**
Permanent „ ...	**12·5**	**16·2**	**20·3**	**20·8**

The temporary alkalinity is given in terms of calcium carbonate, and the permanent alkalinity in terms of sodium carbonate.

These results afford few indications, as shown by the composition of the soil-water, that the cause of the falling-off in yields on the plots manured with nitrate of soda is due to any specific action on the soil. We have an increase in the permanent alkalinity of the soil-water by cultivation, and by manurings with both sulphate of ammonia and nitrate of soda similar to that pointed out in the consideration of the whole of the results.

The most noticeable point is that the relative proportions of magnesium to calcium in the soil-waters from the non-cultivated soil and from the non-manured soil and from that manured with nitrate of soda, the two latter being the soils on which the yields have markedly fallen off in late years, are very different to those in the soil-waters from the soils long manured with sulphate of ammonia. Taking the amounts of calcium present as unity, we get the following molecular ratios:—

	Calcium.	Magnesium.
Not cultivated	1	2·57
Not manured	1	2·40
Nitrate of soda	1	1·52
Sulphate of ammonia ...	1	0·77

Whether there is any signification in these ratios must be the subject of further inquiry.

On the North-east Field which has been under cultivation during six crops only, the mean results referred to chlorine as 100 are as follows :—

	Not cultivated.	Cultivated.	Sulphate of ammonia.
Chlorine	100·0	100·0	100·0
Sulphate ion (SO_4) ...	26·9	17·5	17·6
Carbonate ion (CO_3) ...	13·2	14·6	14·5
Iron	...	1·0	0·2
Calcium	10·2	5·7	5·6
Magnesium	8·6	11·2	10·7
Potassium	0·9	1·4	1·4
Sodium	58·4	56·0	58·1
Total	218·2	207·4	208·1
Temporary alkalinity ...	13·0	10·8	10·8
Permanent „ ...	9·7	12·3	13·8

Although this field has been but a short time under cultivation, the increase in the permanent alkalinity of its soil-water on the parts cultivated but not manured, and on the parts cultivated and manured is noticeable. The molecular relationships of calcium to magnesium are however very different to those recorded as existing in the soil-waters of the longer cultivated field. They are as follows:—

	Calcium.	Magnesium.
Not cultivated	1	1·39
Cultivated, not manured	1	3·26
Cultivated and manured with sulphate of ammonia	1	3·18

THE COMPOSITION OF THE SOIL-WATERS OF THE RICE FIELD.

This field was for many years a practically undrained swamp that supported a heavy growth of 'bush.' A part of it was reclaimed in 1902 and laid out in paddy beds. These beds have been under rice cultivation since that year. The system of cultivation adopted on them is that after the beds of rice are planted in September and October, the land is flooded for some two months and the rice plants allowed to ratoon. After this ratoon crop has been reaped, the land is drained and kept dry, when it soon becomes covered with a heavy growth of grass, sedges, and leguminous plants. These are left to grow until the end of March in the ensuing year when they are cut down, the soil is forked and cultivated, flooded, and planted in rice in April or May. The rice is irrigated for three months and then the water is run off and the crop allowed to mature. Thus the land is under water for about five months in each year, during which it receives altogether about 18 inches in depth of water by irrigation in addition to that of the rainfall. The older bed of the rice field has been exposed to irrigation for five crop years. The rice beds from which the samples were collected have been manured each year with basic superphosphate of lime which supplied a good deal of gypsum to the land; their soil-waters on standing deposited carbonates of calcium in minute crystals.

Samples of soil-water were also taken from adjacent land which has not been cultivated. The composition of the soil-water from the latter, which was obtained at a depth of 2 feet 6 inches, was abnormal and, as shown in the table giving the general results of the examinations of soil-waters, it was of a very high concentration. The water-table below the irrigated land, at about three months after the last application of irrigation-water, was found at a depth of 3 feet 6 inches from the level of the rice beds, or about 20 inches deeper from the

original surface of the land, than it was on the non-cultivated land. The results with chlorine taken as 100 are as follows:—

	Not cultivated and not irrigated.	Cultivated, manured with superphosphate of lime.
Chlorine	100·0	100·0
Sulphate ion (SO_4) ..	18·5	33·8
Carbonate ion (CO_3) ...	7·0	17·3
Iron	0·8	—
Calcium	1·5	5·0
Magnesium	11·6	10·8
Potassium	0·6	1·3
Sodium	55·1	69·9
Total	195·1	238·1
Temporary alkalinity ...	0·7	13·7
Permanent „ ...	5·0	16·1

The contents of the two soil-waters in the nitrate ion and in ammonium are worthy of note. The water from the non-cultivated land contained only 0·027 parts of nitrogen per 1,000,000. This was distributed between 0·038 parts of the nitrate ion, and 0·019 parts of ammonium. The contents of nitrate and of ammoniacal nitrogen in the soil-water from the recently drained swampy land are very low, indicating that little beneficial bacterial action had been able to take place under the unfavourable conditions the soil had been in for very many years. The water from under the rice beds contained 0·443 parts of nitrogen per 1,000,000. This was distributed between 0·366 parts of the nitrate ion, and 0·381 parts of ammonium. These relations show that the irrigation of the land with 'bush water' containing a good deal of organic matter in solution prevents the complete nitrification of the ammonium of the soil-water. Water in which nitrogen is largely present as ammoniacal nitrogen appears specially favourable for the cultivation of rice.

THE COMPOSITION OF SOIL-WATERS FROM THE BOTANIC GARDENS NURSERY.

The composition of two samples of soil-water taken at depths of about 5 feet in the Nursery of the Botanic Gardens is of interest. The first sample is from land which has been under intensive cultivation and repeatedly very heavily manured with stable manure since 1879; the second has been under similar treatment, but between the years 1885 and 1889 it received several very heavy dressings of gypsum. The analytical results compared to chlorine as 100 are as follows:—

	Not plastered.	Plastered 1885-9.
Chlorine	100·0	100·0
Sulphate ion (SO_4)... ...	30·3	41·3
Carbonate ion (CO_3) ...	14·3	13·2
Iron	1·7	—
Calcium	5·7	6·6
Magnesium	8·1	10·3
Potassium	0·5	2·7
Sodium	65·9	64·3
Total	226·5	238·4
Temporary alkalinity ...	8·8	17·7
Permanent „ ...	12·6	4·5

The marked decrease in the permanent alkalinity appears to be due to the dressing with gypsum. The water taken from the plastered soil deposited minute crystals of calcium carbonate on standing. These soil-waters are marked by the high proportion of nitrogen they contain, and by the fact that it is largely in the state of ammoniacal nitrogen; their mean contents of nitrogen being 0·711 parts per 1,000,000, of which 0·562 is in that state. This is doubtless due to the oft-repeated heavy dressings of stable manure supplying more saline nitrogen to the soil than it is capable of nitrifying.

THE RELATION BETWEEN THE TEMPORARY AND PERMANENT ALKALINITY OF THE SOIL-WATERS.

The proportions of the temporary and permanent alkalinity appear to be somewhat obscurely connected with the relationship of the numbers of the molecules of chlorine and of the sulphate ion to those of the carbonate ion present in the water. An increase in the relative proportion of the latter ion appears to be accompanied generally, though not always, by an increase in the proportion of permanent alkalinity.

THE PROPORTION OF NITROGEN IN THE SOIL-WATERS.

It is noticeable that the contents of nitrogen in these tropical soil-waters are distinctly lower than is usually reported as characterizing drainage-water from cultivated land in temperate climates. With exceptions pointed out, the nitrogen in the soil-water other than that possibly found in organic compounds is entirely, or almost entirely present as nitric nitrogen, and it is evident therefore, that nitrification takes place completely in the heavy clay soils of British Guiana.

THE CONCENTRATION OF THE SUBSOIL WATER IN THE SOIL.

The examination of over 100 samples of heavy clay soils from various plantations of British Guiana and of their subsoil waters has shown that when the subsoil water is markedly alkaline and the alkalinity largely permanent during dry seasons, the surface soil becomes more or less strongly alkaline. It is evident that during dry seasons the subsoil water is drawn into the layers of the soil by their capillarity. and there undergoes evaporation with attendant dissociation of the bicarbonates present in it, and the soil becomes more alkaline than is desirable. Examination proved that the excessive alkalinity of the soil during the dry season is due to soluble carbonates--carbonates of sodium, and the double carbonate of sodium and magnesium.

In order to ascertain if concentration of the subsoil water takes place in the upper soil during dry seasons. I had a series of holes dug near to the places whence samples of soil-water had been already collected, on various plots on the South Field to the water-table, and samples of water collected from them. The former samples had been taken during a long spell of rainless weather, the latter were taken two or three days after heavy showers, supplying from 2 to 3 inches of rain, had fallen and the level of the water-table had risen several inches. These showed that concentration had taken place and that the concentrated water had been driven down by and in advance of the newly fallen rain-water. The mean results of six trial-holes in each case were as follows :—

Depth at which water-table was found.		Parts per million.	
		Chlorine.	Total alkalinity.
During dry season,	4 ft. 6ins.	3,177	883
After showers,	3 ft. 9ins.	3,260	905

After rain had set in and fallen for a few days, I had two series of six holes each sunk on various plots in the North Field. Towards the end of the dry season the water-table under the plots and paths on this field had sunk to a depth of nearly 8 feet, after the rains it was at a depth of 4 feet from the surface. The mean results of the two series of observations were :—

	End of dry season.	After commencement of rainy season.
Depth of water-table.	8 feet.	4 feet.
	Parts per 1,000,000.	
Chlorine	3,430	3,390
Sulphate ion (SO_4)	685	540
Carbonate ion (CO_3)	500	495
Iron	8	1
Calcium	157	231
Magnesium	378	339
Potassium	69	27
Sodium	2,020	1,880
Total	7,247	6,906
Nitrate ion (NO_3)	1·427	0·091
Ammonium	Nil	0·605
Total nitrogen	0·326	0·497
Temporary alkalinity ...	367	372
Permanent „ ...	437	452

These figures show indirectly the amount of concentration the water has undergone in the layers of the soil, as the amount of added water necessary to cause supersaturation of 4 feet of subsoil has not appreciably lowered the concentration of the subsoil water.

The relationship in the above of the nitrogen in its distribution in the nitrate and the ammonium ions is of interest. The complete absence of any trace of the ammonium ion in the sample taken during the dry season shows that nitrification in the soil had been complete, whilst the low proportion of the nitrate ion and the high proportion of the ammonium ion in the later taken sample, which consisted, as I have pointed out, largely of concentrated soil-water driven down from the upper

soil, show that during the dry season nitrification is not only more or less suspended but that, probably, denitrification may ensue.

Examinations of several series of soil-waters collected from the level of the water-table during the wet season at the experimental field and on several sugar-cane plantations proved that when the wet season has well set in, the water-table rises to from 2 feet to 2 feet 6 inches below the surface, and that its water then is of very low concentration, containing only 5 parts of chlorine per 1,000,000 whilst, although it is in fertile soils invariably faintly alkaline, its alkalinity is represented by only about 17 parts of calcium carbonate in 1,000,000, and is practically only due to minute amounts of that substance in solution.

SUMMARY.

It is very noticeable that on many long-cultivated heavy clay soils in British Guiana, soon after the dry seasons set in, the plants on them hang back in their growth, and that later they wilt and their foliage becomes burnt. This takes place while the subsoil at depths of a few feet is saturated with water, and whilst the layers of the soil proper only a few inches from the surface are, as regards their contents of moisture, in a condition which should ensure the supply of water requisite to keep the plants in a healthy condition of fairly active growth through a considerable part, if not all, of the dry season.

I have received many samples of soil-water from plantations which are under the charge of members of the Sugar-cane Experiments Committee of the Board of Agriculture of British Guiana. Nearly all of these are alkaline, a few--five out of ninety-eight—being faintly to markedly acid. Several of the alkaline samples were taken from fields on which planters have been compelled to abandon the cultivation of sugar-cane fields which once were very fertile but are now economically barren. These samples as a rule are very markedly alkaline, and the alkalinity is to a great extent of the permanent type, which remains after the dissociation of the bicarbonates.

The injurious effect of dry weather on certain soils seems to be more noticeable now than it was some years ago. This may be in part explained by the increasing contents of the soil-waters in injurious substances, but in part it is doubtless due to the gradual impoverishment of the soil in humus-like constituents.

Soil-waters of the sort now being discussed, containing high proportions of ions which may exist in combination as carbonates of iron, calcium, magnesium, and sodium tend to the formation in the lower layers of the soil or in the subsoil of a hard pan, more or less impervious to water, and above which the earth gradually becomes saturated with concentrated solutions which are injurious to plant-life.

I have, personally, never favoured the readiness so apparent of late years to refer almost every instance of decreased yield

in cultivated plants to the noxious action of microbes or fungi. It appears to me that for a long time back we have in the tropics rather neglected what I may term the physical and chemical hygiene of our cultivated soils, and have not paid sufficient attention to the soil-conditions which may have materially reduced the naturally resistant powers of plants to the attacks of bacteria and fungi. I am inclined to think that in many instances where 'root fungus' is invoked without scientific demonstration of its presence, in explanation of lessened crop yields, the lowering of the crop is due far more to unfavourable hygienic soil-conditions produced by long-continued cultivation, perhaps with little or no utilization of subsoil drainage and of the subsoil plough, than directly to fungus attacks. And further, I think that the susceptibility of certain kinds of plants, for instance, the Bourbon cane, to injury by drought and by fungus attacks is due in part at least to the defective conditions of soil-hygiene under which in places they are now cultivated.

Of course, these detrimental conditions are far more liable to occur on very heavy clay soils which it is practically impossible to drain by subsoil drains than they are on many of the soils of the West India Islands, which have, or are reputed to have, efficient subsoil drainage. But I have seen in Barbados, in Trinidad, and in Antigua, soils giving low returns, which unsatisfactory results may, in my opinion, be due to neglect of soil-hygiene, especially with regard to deep drainage. In these cases I should suggest examination of the nature of their subsoil water as collected at the levels of the water-table.

The practical deductions from the foregoing examinations may be summarized as follows :—

1. That the general reaction of fertile heavy clay soils in British Guiana is, as a rule, slightly alkaline.

2. That this slight alkalinity may be one of the reasons why sulphate of ammonia usually gives better results than does nitrate of soda when these manures are applied in heavy dressings.

3. That the alkalinity enables nitrification to take place readily in the soil during the existence of favourable meteorological conditions.

4. That the alkalinity, replenished as it is by that of the soil-water brought up capillarily during dry seasons, enables sulphate of ammonia to be used year after year without injuring or souring the soil.

5. That the alkalinity of the soil-waters is increased by cultivation and its attendant increased plant-growth, and apparently also by the action of chemical manures on the soil.

6. That in the course of long-continued cultivation the permanent alkalinity of the capillary water of the soil tends to become excessive, with consequent falling-off in the crops.

7. The marked alkalinity and the high contents of salts of magnesium and of sodium chloride of the ascending subsoil water act detrimentally on growing crops during dry seasons

and may be the cause of much of the cessation of active growth, of the wilting, and of the burning of crops soon after the commencement of and during dry seasons.

8. The alkalinity of the soil-water as far as it is not due to dissolved calcium carbonate tends to act detrimentally on the flocculation of the heavy clay soils, and when assisted by the alkali set free from dressings of nitrate of soda tends permanently to reduce the productivity of the soil where the latter substance is applied in large quantities continuously as a manure.

9. That possibly some of the readiness with which certain varieties of tropical plants which have been under intensive cultivation for many years, now appear to fall victims to drought and to fungus attacks is due to defects in the soil and in the soil-waters, the results of long-continued cultivation without adequate deep drainage.

10. The application of heavy and repeated dressings of gypsum seems to be advisable on land the subsoil water of which shows permanent alkalinity to a marked extent. Possibly the use on such land of concentrated superphosphate of lime in place of ordinary superphosphate or of slag phosphate may prove to be advantageous.

CONCLUSION.

I trust that the results of my studies of the composition of soil-waters from lands under sugar-cane cultivation in British Guiana may direct the attention of the chemists and mycologist present at this Conference to the importance of studying the hygiene of the soil on which crops are raised, as well as the life-histories of the microscopic organisms which prey on them whilst growing.

The general principles which I laid before the Conference of 1905 as having been deduced from the experiments carried on in British Guiana between 1880 and 1904, and which are recorded in the *West Indian Bulletin* (Vol. V, pp. 355-6) have been fully confirmed during the crop-years 1905-7.

DISCUSSION.

Dr. Francis Watts (Antigua), adverting to the point brought forward by Professor Harrison in connexion with the acidity of the subsoil, said it was a matter which was deserving of further investigation. In Antigua there were large areas where saline water existed, which he believed was of a different character and brought about by different agencies than those referred to by Professor Harrison. Subsoil drainage, he thought, for Antigua, impossible.

Hon. B. Howell Jones (British Guiana), speaking as a practical planter, pointed out the necessity of planters co-operating with scientific men in carrying out experiments with new varieties of sugar-cane, if the sugar industry of their

colony was to reap the full benefit. One thing which the experiments conducted in British Guiana had taught the planters there was this: that they should be cautious in stating that a certain variety of cane was so much superior to another variety. A cane which suited one locality might prove a failure in another: conditions of soil and climate had always to be taken into consideration. In British Guiana, they were subject to great variations in climate in different parts of the colony. In the upper districts they were generally inundated with a great deal of rain: at other places in the country the rainfall was also abundant. but in some parts long droughts were experienced. Owing to these influences, there was a great variation in the quality and quantity of cane produced per acre. There was one thing that these experiments had taught them, and that was that they had to be exceedingly cautious in stating publicly whether a cane of one variety was very much superior to a cane of another variety. They could only give statistics from their own particular points of view, and in the interesting returns that had been sent in by Professor Harrison and those collected from various planters all over the colony, it was the means of the results that were taken and not the extraordinary yield in one area, or the lesser yield in some other district. In selecting any new varieties of cane for experimentation, the varieties should be experimented with on varieties of soils, under various climatic conditions. And consideration had always to be taken in the yield of tons of sugar per acre, of the milling qualities and capacity of the factory at which that sugar was produced, because it was well known that in some factories a much better extraction was obtained than in others, and the results of one might be extremely good, while the other might be extremely poor. It was the mean results of the large experiments which rendered greater assistance to the general body of planters than those of the minute experiments carried on at the Botanic Stations. The practical planter largely assisted the scientists by sending in carefully prepared returns of results of various canes grown on large areas on his estate. Professor Harrison, he was sure, had the support and help of every practical planter in Demerara in carrying out his experiments, and they were all thankful for the valuable assistance which he had rendered them as Director of Science and Agriculture.

The PRESIDENT, in closing the discussion, said that it was always to be borne in mind in connexion with the experiments carried on at the Botanic Gardens in British Guiana, that the soils were remarkably stiff, and the conditions existing there were such as possibly existed no where else in the West Indies. There were also great variations in the soil and conditions in different districts in British Guiana. Hence, it should not be a matter of surprise if a certain cane proved a failure in one locality and was regarded as the best variety in another. That being so, he did not think that Barbados, British Guiana, Jamaica, or Antigua was in any way prejudiced because a cane that gave good results in one colony did not yield high returns when planted in another colony.

The experiments in the several colonies were conducted on the same lines, and the officers of the Department were quite willing that any cane grown in the West Indies should take its chance elsewhere, and they would be satisfied with the results obtained there. He made those remarks with the object of impressing upon the Conference that there were two classes of experiments carried on at British Guiana: one at the Botanic Gardens by Professor Harrison himself, and the other on estates, and reports were sent in to what was known as the Sugar-cane Experiments Committee, and the difference in conditions of soil and climate had to be taken into account when the results were being considered. Every planter should carry out his own experiments and see what canes were best suited to the conditions existing on his estate.

SUGAR-CANE EXPERIMENTS IN BARBADOS.

BY PROFESSOR J. P. D'ALBUQUERQUE, M.A., F.I.C., F.C.S.,

Island Professor of Chemistry and Chemist-in-charge of

Sugar-cane Experiments, Barbados.

In pamphlet No. 49 issued by the Imperial Department of Agriculture, a copy of which is now before every member of this Conference, there will be found a summary of the most interesting results of our work during the past season. This summary brings to date the published account of the sugar-cane experiments in Barbados, and it will therefore be sufficient for me to-day, on behalf of Mr. Bovell and my other colleagues, to direct your attention to some of the most striking and interesting points.

Our work, as in previous years, may be recorded under two heads. Firstly, there are the experiments with seedling canes, in which an endeavour is being made to raise varieties superior to those at present under cultivation in this island, and secondly, there are being carried out experiments, manurial and otherwise, with a view of ascertaining how to get the most out of the existing varieties.

In the experiments with seedling canes, a very large number of new varieties are raised from seed, and the subsequent work resolves itself into studying the characters of each of these varieties with a view to selecting and perpetuating the very small proportion which, in one or more characters, show themselves superior to the rest. First we study the

field characters with a view to ascertaining what weight of cane the variety will yield to the acre, its power of resistance to insect and fungoid diseases, its behaviour under extremes of dryness and moisture, its period of growth, its germinative and ratooning powers, the magnitude of its leaf production from the point of view of supplying humus to the land and fodder for the cattle, and so on. Inferiority in one or other of the above respects leads to the rejection of a large proportion of the seedlings. The varieties that survive these tests are next crushed and the expression of juice is ascertained and the juice analysed. All but those that yield a fairly rich and pure juice are rejected. Later on, of the few remaining, the milling properties and the fuel-yielding properties have to be considered, and at the end of this long process of selection very few indeed, of many thousand varieties raised, are allowed to remain for continued trial on a gradually increasing scale.

As you are aware, the seed of the cane plant is produced by a sexual process in which two parent plants may participate. We may speak of the mother plant or plant that ultimately bears the seed, and the pollen-bearing plant which bears the dust-like pollen that fertilizes the flower of the mother plant. It would be a great advantage to know exactly the parentage of every seedling cane, because the characters of the seedling, though not obviously a combination of those of the parents, are certainly intimately connected with the characters of the parents, some of which can be discerned and some of which are hidden so that they can only be ascertained by careful and prolonged study. If all the qualities in the parents were known, we should have gone a long way towards knowing what qualities to expect in the offspring. By repeatedly crossing parents in the right way, there is hope of controlling to an important extent the qualities of the offspring.

In raising cane from seed we may therefore adopt either or both of two methods. The easier by far, is to take cane seed as we find it in the field, of which we may only know with certainty the mother plant, that is one half of the parentage of this seed. This is the method which so far has been most largely followed. The other method is to endeavour by various devices to control both parents, and to endeavour to cross known varieties of canes. This is a much more difficult process and has accordingly been only lately shown to be practicable and only followed to a limited extent. It would be a great advantage if we could raise only seed of which both parents were known and controlled, because we believe that there are methods by which this would greatly increase the probability of finding those ideal varieties that we are expending so much labour to produce.

It has been mentioned that Mr. Stockdale, the Mycologist on the staff of the Imperial Department of Agriculture, had attacked the problem, and all who realize the importance of his work will hope that he may be able to carry it on long enough to bring it to a successful issue.

I do not propose to-day to detain you with any detailed account of how we raise the seedlings from seed and test them on a gradually increasing scale in field and laboratory and factory: all this is well known to you and can be found in the previous reports published. It is sufficient to state that over 30,000 varieties have been raised from seed during the last ten years and are in various stages of the testing process. Some of these varieties show great promise, and they have during the last year been grown upon eleven black-soil estates and three red-soil estates. The growth of the varieties in all parts of this island enables us to try the varieties in every typical soil, and under every typical climatic condition existing in Barbados. The canes being cultivated in the same way as the rest of the canes on the same estate are grown under practical working estate conditions. We therefore regard the results as practical results, and when we recommend a variety on these results, we feel that planters are justified in giving that variety a trial on their estates on a small scale. It is for the planter to select ultimately from among the few varieties that we recommend those that are most suitable to his own conditions. To further ensure the trial of the most promising of the new varieties in an expeditious and economical manner all over the island, we have succeeded in establishing 1-acre plots of those varieties in a large number of representative estates. This means that as soon as the smaller plots have given results of sufficient promise, the variety will be rapidly multiplied and tested on 1-acre plots in all parts of the island. These plots will not only serve to show in a striking manner to the planters in that locality, the capabilities of the variety, but also to form a means of supplying a comparatively large number of tops for propagation.

RECENT RESULTS.

The rainfall in December 1905 and January 1906 was, on the whole, below the average. The cane cuttings, however, that were planted at an early time grew fairly regularly, but those that were planted at the close of the year did not germinate so well, and as the rainfall during the dry season, i.e., from February to the end of May, was also below the average, a regular stand of canes was not obtained as early as usual. The rainy season commenced in June and, the rainfall conditions being favourable, the canes made considerable progress until the end of November, when a drought set in which continued until the end of the reaping season. The effect of these conditions of rainfall was to make the canes somewhat dry, and to reduce the yield in many instances below the average. This was especially noticeable with the ratoons, the growth of which was much retarded by the sugar-cane root fungus (*Marasmius Sacchari*).

I will now direct your attention to the following table of the selected varieties arranged in order of yield to show the relative position and purity of juice of certain canes in different soils, and also when grown as plants and ratoons ;—

THE SELECTED VARIETIES ARRANGED IN ORDER OF YIELD TO SHOW THE RELATIVE POSITION AND PURITY OF JUICE OF CERTAIN CANES IN DIFFERENT SOILS, AND ALSO WHEN GROWN AS PLANTS AND RATOONS.

1907.

Variety.	Saccharose in pounds per acre. Plants.	Ratoons.	Average.	Purity of Juice.*
BLACK SOILS.				
B. 3,696	8,916			high
B. 208	8,365	2,416	5,391	high
B. 147	7,793			fair
B. 3,635	7,455			high
D. 95	7,315	2,965	5,140	high
B. 1,753	7,274			fair
B. 376	7,123	2,686	4,905	high
B. 1,529	7,090			high
White Transparent	6,871	2,978	4,925	high
RED SOILS.				
B. 3,405	10,792			fair
B. 3,412	9,589			fair
B. 3,390	9,536			fair
B. 1,753	8,674			fair
B. 1,566	8,394	6,645	7,520	high
B. 3,696	7,194			fair
B. 1,529	6,864	2,449	4,657	high
B. 376	6,423	6,586	6,505	high
B. 208	6,410	5,660	6,035	high
D. 95	6,266	7,591	6,929	high
White Transparent	6,006	5,736	5,871	high

* Juices are classified as follows :

Quotient of purity *above* 90 ... high.
,, ,, ,, 90-85 ... fair.
,, ,, ,, *below* 85 ... low.

You will note that nine varieties were grown as plants in black soils, and of these three varieties showed a substantial advance on the White Transparent cane. B. 147 shows an advance in sugar of 12 per cent. on the White Transparent, B. 208 an advance of nearly 20 per cent., and B. 3,696 an advance of nearly 30 per cent. In red soils, ten varieties were grown in comparison with the White Transparent. Five varieties were grown only as plants, and all, as plants, gave results showing advances of from 15 per cent. to 45 per cent. on the White Transparent. Four varieties grown as plants and ratoons showed as plants and ratoons taken together advances of 3 per cent. to nearly 30 per cent. on the White Transparent.

B. 3,405 stood at the top of the 'plant canes' (not having been ratooned), and B. 1,566 stood at the top of plants and ratoons taken together.' It will be noted that in respect of the purity of the juice all these varieties were fair to good, an important point in muscovado manufacture.

The table on pages 44 and 45 gives the results of some larger estate plots (½-8 acres in area) of seedling canes grown during 1907 crop in comparison with White Transparent.

It will be observed that at Jordans B. 208 gave an increase of nearly a ton of saccharose per acre. At Husbands plantation, St. Lucy, B. 147, and B. 208 each gave an increase of over ½ ton of saccharose over the White Transparent. At Carrington plantation, St. Philip, B. 147 gave an increase of more than ½ ton of saccharose per acre over White Transparent.

RESULTS OF THE LARGE VARIETY EXPERIMENT PLOTS.

(Plant Canes.)

Date. 1907.	Name of Estate.	Name of Field.	Number or Name of Cane.	Size of Plot. Acres.	Normal Juice. Sp. Gr. $\frac{30^\circ C.}{16{\cdot}6^\circ C.}$	Normal Juice. Pounds per gallon. Saccharose.	Normal Juice. Pounds per gallon. Glucose.	Normal Juice. Pounds per gallon. Solids not Sugar.	Normal Juice. Quotient of Purity.	Normal Juice. Glucose Ratio.	Gallons of Juice per acre. (Imperial Gallons.)	Saccharose lb. per acre.
March 27	Carrington	Heavy Foot	B. 376	·5 ac.	1·0800	1·993	·061	·128	91·34	3·06	2,820	5,660
			White Transpt.	·5 „	1·0870	1·999	·066	·305	84·35	3·30	2,960	5,918
			B. 208	·5 „	1·0884	2·171	·048	·186	90·27	2·21	2,800	6,078
			B. 147	·5 „	1·0765	1·902	·089	·097	91·09	4·68	3,800	7,228
„ 14	Jordans	Upper Horse Pond	White Transpt.	1 „	1·0795	2·006	·063	·101	92·44	3·14	2,527	5,069
			B. 208	1 „	1·0791	1·960	·068	·130	90·82	3·47	3,699	7,250

RESULTS OF THE LARGE VARIETY EXPERIMENT PLOTS.

(Plant Canes.)

Date. 1907.	Name of Estate.	Name of Field.	Number or Name of Cane.	Size of Plot. Acres.	Normal Juice. Sp. Gr. $\frac{30° C.}{16·6° C.}$	Normal Juice. Pounds per gallon. Saccharose.	Normal Juice. Pounds per gallon. Glucose.	Normal Juice. Pounds per gallon. Solids not Sugar.	Normal Juice. Quotient of Purity.	Normal Juice. Glucose Ratio.	Gallons of Juice per acre. (Imperial Gallons.)	Saccharose lb. per acre.
March 5	Husbands	Cocoa-nut	White Transpt.	1·054 ac.	1·0787	1·950	·068	·129	90·82	3·49	3,210	6,318
			B. 1,753	1·07 ,,	1·0756	1·805	·089	·171	87·41	4·93	3,659	6,604
			B. 208	1·05 ,,	1·0839	2·096	·068	·123	91·65	3·24	3,649	7,648
			B. 147	·98 ,,	1·0756	1·840	·096	·129	89·10	5·22	4,165	7,664
,, 14	Upton	Hog Hole	White Transpt.	8 ,,	1·0760	1·847	·061	·169	88·93	3·30	3,670	6,779
,, 22	,,	,,	B. 208	2 ,,	1·0844	2·138	·044	·223	88·90	2·06	3,524	7,534
April 23	,,	Stoke Hole	White Transpt.	2 ,,	1·0826	1·788	·132	·332	79·40	7·38	3,119	5,720
			B. 147	1·5 ,,	1·0822	1·899	·093	·248	84·78	4·90	3,599	6,835

In the following table will be found the results obtained with the selected varieties arranged in order of yield, to show the relative position and purity of juice of certain canes in different soils, and also when grown as plants and ratoons:—

THE SELECTED VARIETIES ARRANGED IN ORDER OF YIELD, TO SHOW THE RELATIVE POSITION AND PURITY OF JUICE OF CERTAIN CANES, IN DIFFERENT SOILS, AND ALSO WHEN GROWN AS PLANTS AND RATOONS.

1900-7.

Variety.	Saccharose in pounds per acre. Plants.	Ratoons.	Average.	Purity. of Juice.
BLACK SOILS.				
B. 3,696	9,054			high
B. 3,635	7,888			high
B. 1,753	7,526			fair
B. 208	7,171	3,585	5,378	high
B. 147	7,082			fair
B. 376	6,606	3,418	5,012	high
White Transparent	6,586	3,461	5,024	fair
D. 95	6,412	3,736	5,074	high
RED SOILS.				
B. 3,405	10,208			fair
B. 3,412	9,975			fair
B. 3,390	9,569			fair
B. 1,566	8,812	6,094	7,453	high
B. 1,529	7,356			high
B. 208	6,718	4,981	5,850	high
B. 376	6,574	6,280	6,427	fair
D. 95	6,225	6,307	6,266	high
White Transparent	5,604	5,277	5,441	high

These varieties have been grown on the ordinary small plots between 1900 and 1907. In black soils, seven varieties were grown as plants in comparison with the White Transparent, and of these, six varieties, showed advances on the White Transparent of 1 per cent. to nearly 40 per cent. B. 147 showed an advance of 8 per cent., B. 208, 10 per cent., and three

of the newer varieties, namely B. 1,753, B. 3,635, and B. 3,696 show advances of 15 per cent. to 40 per cent. In red soils, eight varieties were grown in comparison with the White Transparent, four as plants and only four as plants and ratoons. The four varieties grown only as plants show advances on White Transparent of 30 per cent. to 80 per cent., and the four varieties grown as plants and ratoons taken together show advances of from 8 per cent. to 37 per cent. B. 208 shows the advance as plants and ratoons of 8 per cent., B. 1,566, the advance of 37 per cent. These results are all on small plots.

The following tables give some very interesting extracts from the results of three and four years' comparative growth of some of the newest seedlings in comparison with some of the older seedlings and the White Transparent variety.

In black soils, the results with some of the best varieties as plant canes for the last four years are as follows :—

Variety.	Saccharose. Pounds per acre.	Muscovado Sugar. Pounds per acre.	Increase in value per acre, compared with White Transparent.
White Transparent	6,670	5,336	
B. 376	6,810	5,448	$ 2·03
B. 208	7,328	5,862	9·52
B. 147	7,474	5,979	11·64
B. 1,529	7,787	6,230	16·18
B. 1,753	8,860	7,088	31·71
B. 3,696	9,054	7,243	34·52

In black soils, the average yields of plants and ratoons, taken together, were per acre per annum :—

Variety.	Saccharose. Pounds per acre.	Muscovado Sugar. Pounds per acre.
White Transparent	5,197	4,158
B. 208	5,542	4,434

In red soils, the results are more striking. The average yields per acre for plant canes for the four years 1904-7 were as follows:—

Variety.	Saccharose. Pounds per acre.	Muscovado Sugar. Pounds per acre.	Increase in value per acre, compared with White Transparent.
White Transparent	6,125	4,900	
D. 95	6,732	5,386	$ 8·80
B. 376	7,252	5,802	16·33
B. 1,529	7,356	5,885	17·83
B. 208	7,703	5,162	22·84
B. 1,566	8,812	7,050	38·91
B. 3,390	9,569	7,655	49·87
B. 3,412	9.975	7,980	55·75
B. 3,405	10,208	8,166	59·11

If the average results for plants and ratoons on the red soils are now considered together, for the same period, the yields per acre per annum are as follows:—

Variety.	Saccharose. Pounds per acre.	Muscovado Sugar. Pounds per acre.	Increase in value per acre, compared with White Transparent.
White Transparent	6,016	4,813	
B. 208	6.577	5,262	$ 8·13
D. 95	6,748	5,398	10·59
B. 376	6,766	5,412	10·84

For the black soils as plants on the average for three and four years, White Transparent came out ninetieth with 6,670 ℔. of saccharose, while the seven best varieties gave over 9,000 ℔. of saccharose per acre, the increases being worth $33·79 and upwards per acre more than the White Transparent. The following is taken from the results obtained :—

Variety.	No. of years under experiment.	No. of Experiments.	Saccharose. Pounds per acre.	Increase in value per acre, compared with White Transparent.
White Transparent	4	84	6,670	
B. 208	4	55	7,342	$ 9·74
B. 147	4	17	7,474	11·64
B. 1,753	4	16	8,872	31·89
B. 6,308	3	3	8,982	33·48
B. 6,450	3	5	9,004	33·79
B. 3,922	3	3	9,224	36·98
B. 6,346	3	3	9,270	37·65
B. 3,696	4	11	9,353	38·84
B. 3,747	3	3	9,503	41·01
B. 3,675	3	3	9,679	43·57
B. 6,204	3	3	10,120	49·96

Coming now to the results for the present year, in black soils as plant canes :—

Variety.	Saccharose. Pounds per acre.	Muscovado sugar. Pounds per acre.	Increase in value per acre, compared with White Transparent.
White Transparent	6,871	5,497	
B. 1,529	7,090	5,672	$ 3·17
B. 376	7,123	5,698	3·64
B. 1,753	7,274	5,819	5·83
D. 95	7,315	5,852	6·43
B. 3,635	7,455	5,964	8·45
B. 147	7,793	6,234	13·34
B. 208	8,365	6,692	21·63
B. 3,696	8,916	7,133	29·61

In the red soils, taking plants and ratoons together for three years, we find the following :—

Variety.	Saccharose pounds per acre.			Total increase in value per acre, compared with White Transparent.
	Plants.	Ratoons.	Total.	
White Transparent	5,916	6,932	11,948	
B. 208	7,263	5,490	12,753	$ 11·66
B. 376	7,018	6,167	13,185	17·92
D. 95	6,802	6,771	13,573	23·53
B. 1,566	9,168	5,674	14,842	11·92
B. 3,390	9,548	6,954	16,502	65·96
B. 3,405	10,509	6,075	16,584	67·13
B. 3,412	10,650	6,799	17,449	79.66

In red soils, plants and ratoons, the following results for the present year are worthy of notice :—

Variety.	Saccharose pounds per acre.			Total increase in value per acre, compared with White Transparent.
	Plants.	Ratoons.	Total.	
B. 1,529	5,864	2,449	9,313	
White Transparent	6,006	5,736	11,742	
B. 208	6,410	5,660	12,070	$ 4·74
B. 376	6,423	6,586	13,009	18·34
D. 95	6,266	7,591	13,857	30·63
B. 1,566	8,394	6,645	15,039	47·73

NEW SEEDLINGS.

Of the 4,874 seedling canes which were planted in 1905, 126 from their field characters, and the richness and purity of their juice passed the standard and were replanted. From these, 118 varieties were obtained, and they will be replanted at the close of 1907.

At the end of 1906, owing to the unfavourable weather conditions, only 249 seedlings were obtained. These were transplanted in due course and will be tested during the reaping season of 1908, and all the stools of the best varieties will be replanted.

It has been mentioned in previous reports that artificial hybridization had been successfully performed. From the canes so obtained, the following varieties are under experimental cultivation at present, viz.—B. 11,629, B. 11,660, B. 11,692, B. 11,724, and B. 11,756.

In addition, the following six varieties obtained from arrows bagged to prevent cross-fertilization, are being grown, viz.—B. 11,360, B. 11,385, B. 11,482, B. 11,788, B. 11,820, and B. 11,852.

None of these, however, we regret to state, show any indication of giving better results than some of the newer seedlings at present under cultivation.

In 1902, a number of the seedling canes B. 208 and D. 95 were planted in alternate rows, and in alternate holes in the rows, i.e., chess-board fashion, in such a position that they would not be likely to be cross-fertilized by canes of other varieties.

From these canes were obtained 196 seedlings. From their field characters and saccharose content, fourteen have been thought worthy of further trial. Of these fourteen, five resemble the D. 95, four resemble the B. 208, four partake of the nature of both canes, and one resembles neither.

These canes were tested this season, but three only of the fourteen gave better results than the White Transparent grown in the same field. The following shows the position in which they stand :—

Variety.	Saccharose pounds per acre.
White Transparent	5,819
B. 8,528	5,905
B. 8,565	6,158
B. 8,520	7,189

FUTURE WORK.

Recently, Mr. F. A. Stockdale has been en-gaged in hybridizing some of the best of the seedling canes, in bagging arrows of some of the better varieties planted in chess-board fashion for the purpose of obtaining hybrids by natural methods, i.e., bagging, say, B. 376, a cane with little fertile pollen, with B. 208, a cane with much fertile pollen, and in bagging canes of different varieties to obtain self-fertilized seedlings. The seeds obtained from the results of this work will shortly be planted, and it is hoped that a number of new seedlings will be raised.

In addition, a number of sugar-cane seeds obtained in the usual manner have been sown, and are at present germinating satisfactorily.

MANURIAL EXPERIMENTS.

The manurial experiments have been carried out at Dodds Botanic Station and at five sugar estates situated in typical parts of the island. Of these six stations, five, namely, Dodds, Foursquare, Ruby, Hampton, and Balls are black-soil estates, while one, namely Hopewell, is a red-soil estate.

The experiments at Hopewell comprised a field of plant canes, one of first ratoons, and one of second ratoons; the other experimental fields contained plant canes.

The plots at Ruby, Hampton, and Balls were each approximately 1 acre in area. Those at Dodds, Foursquare, and Hopewell were respectively, $\frac{1}{20}$, $\frac{1}{4}$, and $\frac{1}{7}$ acre. As in previous years, the small plots were arranged so that the canes of one plot did not interfere with the growth of the canes of the neighbouring plots, and the cultivation of the fields, though differing in detail, was similar to that practised in all parts of the island. The results therefore may be taken with confidence as indicating what, under the weather conditions of the season, would be obtained on a large scale in similar fields in the same localities.

The experiments were, for the most part directed, as in former years, with a view to ascertaining the effect of the application of farmyard manure, sulphate of ammonia, nitrate of soda, superphosphate, basic slag, and sulphate of potash upon the industrial yield of the sugar-cane.

Upon the whole, they indicate, as in previous years, that an ordinary application of manure plus artificials is more effective than a very large application of farmyard manure without artificials: that after an ordinary application of farmyard manure, the application of nitrogen, both to plant canes and ratoons, is followed generally by a large and profitable increase of yield; and that this year again, the results of the application of phosphatic manure and sulphate of potash varied, in some cases being followed by a notable increase of yield.

The results of the application of minerals to cane fields under ratoons or intended for ratooning, which had, previously to planting, received a very large application of farmyard manure also varied considerably in different fields, and the results are best understood by reference to what follows.

DODDS BOTANIC STATION.

This series consisted of twenty-six plots each of $\frac{1}{20}$ acre in area. They were a continuation of the experiments conducted in the same field since 1893. The variety of cane grown in this field was White Transparent. The plot that received 20 tons of farmyard manure but no artificials gave 23 tons of cane; the plot that received an additional 20 tons of farmyard manure gave 31 tons of cane; while plots that received 20 tons of farmyard manure and artificials gave yields up to 39·75 tons of cane per acre.

It would appear again this year, therefore, that artificial manures, added after an ordinary application of farmyard manure, are more effective than very large applications of farmyard manure without artificials.

The plot that received minerals but no nitrogen gave 29 tons of cane; the plot that received minerals and 40 lb. nitrogen as sulphate of ammonia (15 lb. in January and 25 lb. in June) gave 32·25 tons of cane; and the plot that received minerals and 60 lb. of nitrogen as dried blood, partly in January and partly in June, gave 34·75 tons of cane per acre.

The plot that received nitrogen and potash, but no phosphate, gave 32·25 tons of cane, while the plot that received, in addition, 80 lb. of phosphate as basic slag, gave 39·75 tons of cane—a gain of 7·5 tons of cane per acre.

The plot that received nitrogen and phosphate, but no potash, gave 33·75 tons of cane, while the plot that received in addition 60 lb. of potash (as sulphate), half in January and half in June, gave 36·5 tons of cane—an increase of 2·75 tons of cane.

The most favourable result of the application of artificial manure was given by the plot that received 80 lb. of phosphate as basic slag in January, 60 lb. of potash as sulphate in January, and nitrogen (as sulphate of ammonia) 15 lb. in January and 45 lb. in June. This plot gave about 40 tons of cane per acre—an increase of about 17 tons of cane by artifical manure. The value of this increased yield was $51·00, the cost of the manure was $15·36, and the net profit $35·64 per acre.

FOURSQUARE.

At this station, the plots were twenty-four in number, each of the approximate area of ¼ acre, and occupied a total area of nearly 6 acres. The variety under cultvation was B. 147. The whole field received 20 tons of farmyard manure per acre. In this field, the application of nitrogen as sulphate of ammonia increased the yield; an application of 40 lb. nitrogen giving an increase of 6 tons of cane per acre, and an application of 80 lb. of nitrogen giving an increase of 7·5 tons of cane per acre. The plot that received 100 lb. of phosphate as basic slag gave about 1 ton of cane per acre more than the no-phosphate plot. The application of potash did not appear to lead to increased yields.

HOPEWELL.

At this red-soil estate, three fields were under experimental cultivation, 'Ten Acre' field containing second ratoons in continuation of the experiments with first ratoon canes in the same field. The plots in this field were fifty-two in number, each of the area of ¼ acre, and every experiment was conducted in quadruplicate. The variety under cultivation was the Rappoe.

This series of plots this year completes the experiments conducted through three crops: namely, plants, first ratoons,

and second ratoons. Prior to the planting of the canes, a very large quantity (42 tons per acre) of farmyard manure was applied to the whole field. The results of the further application of artificial manures taken for the three crops together indicate that:—

(1) The application of artificial manures led, in the most favourable instance, to a total increase of 33 tons of cane per acre, that is, an average of 11 tons per acre per annum. The manuring consisted of 50 lb. of phosphate as superphosphate, 50 lb. of potash as sulphate, and 80 lb. of nitrogen as sulphate of ammonia and nitrate of soda each year. The total cost of this manure was $51·63, the value of the increased yield of canes was $99·00, making the net profit by manuring $47·37 per acre, or an average of $15·79 per acre per annum.

(2) The plot that received 60 lb. of nitrogen per annum gave a total increase for the three years of 25 tons of cane. The net profit by manuring in this case was $45·84 per acre, or an average of $15·28 per acre per annum.

In 'Six Acre' field, there were twenty-five plots of first ratoons, being a continuation of the experimental plots reaped as plant canes in the preceding year. Each plot was $\frac{1}{7}$ acre in area and all the experiments were conducted in duplicate. The variety under cultivation was White Transparent. This field received, before planting in 1905, 40 tons of farmyard manure per acre.

The results of the two crops taken together, indicate that the application of artificial manures gave an increase of 17 tons of cane—an increase due mainly to the application of nitrogen, to a lesser extent to the application of potash, and not perceptibly to the application of phosphate. The application of 60 lb. of nitrogen as sulphate of ammonia to plants, and of 60 lb. of nitrogen (40 lb. as sulphate of ammonia and 20 lb. as nitrate of soda) to ratoons gave a total increase over the two crops of 17 tons of cane, with a net profit of $31·56 per acre for two years, or an average profit of $15·78 per acre per annum.

HAMPTON.

The 1-acre experiments at Hampton plantation show no profitable increase of yield resulting from the application of nitrogen, but the absence of a duplicate to the no-nitrogen plot renders the result inconclusive.

RUBY.

At Ruby plantation, the application of 100 lb. of phosphate as basic slag gave an increase of about 3·5 tons of cane over no phosphate.

BALLS.

At Balls plantation, the application of 50 lb. of potash (as sulphate) gave an increase of 500 lb. of saccharose per acre, and an application of 100 lb. of potash (as sulphate gave an increase of 800 lb. of saccharose. The canes were not weighed on this plantation.

TABLE I.

Dodds Manurial Plots. Nitrogen Series. Summervale Field.

Plots.		January. lb.	June. lb.	Total. lb.	Canes. Tons per acre.	Saccharose. Pounds per acre.	Difference by Manuring. Canes. Tons per acre.	Difference by Manuring. Saccharose. Pounds per acre.
A 1	Nitrogen	0	0	0	23·08	7,104		
	Phosphate	0	0	0				
	Potash	0	0					
B 1	Nitrogen	Farmyard manure, 20 Tons.			30·79	9,143	+7·71	+2,039
	Phosphate							
	Potash							
A 2	Nitrogen	0	0	0	29·00	9,395	+5·92	+2,291
	Phosphate	80	0	80				
	Potash as sulphate	60	0	60				
A 3	Nitrogen as sulphate of ammonia ...	0	40	40	31·22	9,270	+8·14	+2,166
	Phosphate	80	0	80				
	Potash as sulphate	60	0	60				
A 4	Nitrogen as sulphate of ammonia ...	0	60	60	32·19	9,810	+9·11	+2,706
	Phosphate	80	0	80				
	Potash as sulphate	60	0	60				

TABLE I.—(*Continued.*)

DODDS MANURIAL PLOTS. NITROGEN SERIES. SUMMERVALE FIELD.

Plots.		January. lb.	June. lb.	Total. lb.	Canes. Tons per acre.	Saccharose. Pounds per acre.	Difference by Manuring. Canes. Tons per acre.	Difference by Manuring. Saccharose. Pounds per acre.
A 6	Nitrogen as sulphate of ammonia ...	0	80	80	30·83	8,917	+7·75	+1,813
	Phosphate	80	0	80				
	Potash as sulphate	60	0	60				
B 3	Nitrogen as sulphate of ammonia ...	15	25	40	32·27	9,452	+9·19	+2,348
	Phosphate	80	0	80				
	Potash as sulphate	60	0	60				
A 5	Nitrogen as sulphate of ammonia ...	15	45	60	29·25	8,639	+6·17	+1,553
	Phosphate	18	0	80				
	Potash as sulphate	60	0	60				
B 4	Nitrogen as nitrate of soda	0	60	60	30·49	9,450	+7·41	+2,346
	Phosphate	80	0	80				
	Potash as sulphate	60	0	60				

TABLE I.—(*Concluded.*)

DODDS MANURIAL PLOTS. NITROGEN SERIES. SUMMERVALE FIELD.

Plots.		January. lb.	June. lb.	Total. lb.	Canes. Tons per acre.	Saccharose. Pounds per acre.	Difference by Manuring. Canes. Tons per acre.	Difference by Manuring. Saccharose. Pounds. per acre.
B 7	Nitrogen as dried blood	15	25	40	31·57	9,292	+ 8·49	+2,188
	Phosphate	80	0	80				
	Potash as sulphate	60	0	60				
B 5	Nitrogen as dried blood	15	45	60	34·72	0,430	+11·64	+3,326
	Phosphate	80	0	80				
	Potash as sulphate	60	0	60				
B 2	Nitrogen as dried blood	40	0	40	31·25	9,110	+ 8·17	+2,006
	Phosphate	80	0	80				
	Potash as sulphate	60	0	60				
B 6	Nitrogen as dried blood	60	0	60	33·68	9,916	+10·60	+2,812
	Phosphate	80	0	80				
	Potash as sulphate	60	0	60				

TABLE II.

DODDS MANURIAL PLOTS. PHOSPHATE SERIES. SUMMERVALE FIELD.

Plots.		January. lb.	June. lb.	Total. lb.	Canes. Tons per acre.	Saccharose. Pounds per acre.	Difference by Manuring. Canes. Tons per acre.	Difference by Manuring. Saccharose. Pounds per acre.
A 1	Nitrogen	0	0	0	23·08	7,104	...	...
	Phosphate	0	0	0				
	Potash	0	0	0				
B 1	Nitrogen	Farmyard manure, 20 Tons.			30·79	9,143	+7·71	+2,039
	Phosphate							
	Potash							
A 7	Nitrogen as sulphate of ammonia ...	15	45	60	32·34	9,436	+9·26	+2,332
	Phosphate as superphosphate	0	0	0				
	Potash as sulphate	60	0	60				
B 8	Nitrogen as sulphate of ammonia ...	15	45	60	32·84	9,035	+9·76	+1,931
	Phosphate as superphosphate	40	0	40				
	Potash as sulphate	60	0	60				
A 5	Nitrogen as sulphate of ammonia ...	15	45	60	29·25	8,639	+6·17	+1,535
	Potash as superphosphate	80	0	80				
	Potash as sulphate	60	0	60				

(TABLE II.—*Concluded.*)

DODDS MANURIAL PLOTS. PHOSPHATE SERIES. SUMMERVALE FIELD.

Plots.		January. lb.	June. lb.	Total. lb.	Canes. Tons per acre.	Saccharose. Pounds per acre.	Difference by Manuring.	
							Canes. Tons per acre.	Saccharose. Pounds per acre.
B 9	Nitrogen as sulphate of ammonia ...	15	45	60	32·44	9,239	+9·36	+2,135
	Phosphate as superphosphate ...	120	0	120				
	Potash as sulphate	60	0	60				
A 8	Nitrogen as sulphate of ammonia ...	15	45	60	31·33	8,785	+8·25	+1,681
	Phosphate as superphosphate ...	40	40	80				
	Potash as sulphate	60	0	60				
A 9	Nitrogen as sulphate of ammonia ...	15	45	60	33·78	9,364	+10·70	+2,260
	Phosphate as superphosphate ...	60	60	120				
	Potash as sulphate	60	0	60				
B 13	Nitrogen as sulphate of ammonia ...	15	45	60	39·72	11,129	+16·64	+4,025
	Phosphate as basic slag	80	60	80				
	Potash as sulphate	60	0	60				
A 13	Nitrogen as sulphate of ammonia ...	15	45	60	32·87	8,886	+9·79	+1,782
	Phosphate as basic slag	100	0	100				
	Potash as sulphate	60	0	60				

TABLE III.

Dodds Manurial Plots. Potash Series. Summervale Field.

Plots.		January. lb.	June. lb.	Total. lb.	Canes. Tons per acre.	Saccharose. Pounds per acre.	Difference by Manuring. Canes. Tons per acre.	Difference by Manuring. Saccharose. Pounds per acre.
A 1	Nitrogen	0	0	0	23·08	7,104		
	Phosphate	0	0	0				
	Potash as sulphate	0	0	0				
B 1	Nitrogen	Farmyard manure, 20 Tons.			30·79	9,143	+ 7·71	+2,039
	Phosphate							
	Potash as sulphate							
B 10	Nitrogen as sulphate of ammonia ...	15	45	60	33·89	9,379	+10·81	+2,275
	Phosphate	80	0	80				
	Potash as sulphate	0	0	0				
A 10	Nitrogen as sulphate of ammonia ...	15	45	60	33·12	8,883	+10·04	+1,779
	Phosphate	80	0	80				
	Potash as sulphate	40	0	40				
A 5	Nitrogen as sulphate of ammonia ..	15	45	60	29·25	8,639	+ 6·17	+1,535
	Phosphate	80	0	80				
	Potash as sulphate	60	0	60				

TABLE III.—(*Concluded.*)

DODDS MANURIAL PLOTS. POTASH SERIES. SUMMERVALE FIELD.

Plots.		January. lb.	June. lb.	Total. lb.	Canes. Tons per acre.	Saccharose. Pounds per acre.	Difference by Manuring. Canes. Tons. per acre.	Difference by Manuring. Saccharose. Pounds per acre.
A 11	Nitrogen as sulphate of ammonia ...	15	45	60	34·28	9,136	+ 11·20	+ 2,032
	Phosphate	80	0	80				
	Potash as sulphate	80	0	80				
A 12	Nitrogen as sulphate of ammonia ...	15	45	60	33·02	8,679	+ 9·94	+ 1,575
	Phosphate	80	0	80				
	Potash as sulphate	100	0	100				
B 12	Nitrogen as sulphate of ammonia ...	15	45	60	36·47	9,748	+ 13·39	+ 2,644
	Phosphate	80	0	80				
	Potash as sulphate	30	30	60				
B 11	Nitrogen as sulphate of ammonia ...	15	45	60	32·83	8,701	+ 9·75	+ 1,597
	Phosphate	80	0	80				
	Potash as sulphate	40	40	80				

DISCUSSION.

Mr. A. P. COWLEY (Antigua) mentioned that the manurial experiments at Barbados showed that artificials added to farmyard manure gave increased yields, while the experiments at Antigua gave results which indicated that a normal application of farmyard manure was quite sufficient for the successful growth of plant canes. Such differences as these indicated the necessity of having reliable experiments established in the different islands, and the results obtained showed the necessity of having a well-organized Agricultural Department in their midst. Information was also required in reference to the difference of results obtained from seedling canes when planted at different periods of the year, and to the length of maturity of several of these canes. For instance, he found that B. 208 matured in ten months, whereas B. 147 took from sixteen to eighteen months to mature. Again, a great deal depended on the month in which they were planted. If planted in a certain month the growth and yield seemed greater than if planted in other months.

Professor D'ALBUQUERQUE said he was not intimately acquainted with Antigua, but he thought he could point to one or two factors in Barbados which did not exist in Antigua. First of all, the majority of the soils in Barbados were very thin and were underlaid by coral rock, so that the drainage was very complete, and in many instances, he might say, very severe. The leaching of the soil was also another very prominent feature. Then again, in Barbados, the acreage of pasturage was comparatively small, and he imagined, therefore, that the quantity and value of farmyard manure which was available in Antigua might be greater than that of an average-sized estate in Barbados. He thought both of those factors might explain why more artificial manure was required in Barbados than in Antigua.

The PRESIDENT observed that Dr. Watts' experiments had shown conclusively, that under the conditions obtaining in Antigua, no artificial manures were necessary for plant canes. In the case of Barbados, the conditions here were such that it was desirable to use farmyard manure, and in addition to that, a reasonable quantity of artificial manure With regard to the other point raised by Mr. Cowley, namely, planting different canes at different seasons, he pointed out that the two canes referred to, B. 147 and B. 208, were planted at different seasons, and that B. 147 required a long time for its growth, while B. 208 usually matured in a much shorter period. The experiments carried out in the Leeward Islands dealt with that point. The two canes required different treatment, and that was a practical question for practical planters.

SUGAR-CANE EXPERIMENTS IN THE LEEWARD ISLANDS.

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This work was reviewed in a paper presented to the Agricultural Conference held at Jamaica in 1907, and appeared in the *West Indian Bulletin*, Vol. VIII, pp. 28-50. Since that period, the work has been carried on with some modifications. The results are to be found in the annual report issued by the Imperial Department of Agriculture (Report on Sugar-cane Experiments in the Leeward Islands, 1906-7, Parts I and II), and in pamphlet form (Pamphlets Nos. 50 and 51).

VARIETIES OF SUGAR-CANE.

The varieties of canes under experiment are planted in single or double rows. In a few instances triple rows are employed. It is believed that the method of comparing canes planted in rows, rather than in rectangular plots presents several advantages when experimenting with varieties of sugar-cane.

These experiments are situated in the ordinary fields of sugar-cane, and it is an essential feature that the canes shall be cultivated in the same manner as the ordinary crop of the estate, so as to institute a close comparison on the most practical basis between these canes and those ordinarily grown.

The experiments with varieties of sugar-cane go to show that the canes Sealy Seedling, B. 208, D. 625, B. 156, D. 109, and B. 306 are suitable for cultivation in Antigua, while in St. Kitt's, B. 208 and D. 116 have given good results on the experiment plots.

B. 147 is a variety which is more extensively planted in St. Kitt's than any other. For the crops to be reaped in 1908, an area of 2,708 acres out of a total area of 7,506 acres is planted in B. 147. Its cultivation is being rapidly extended in Antigua for 509½ acres are reported from seventy-five estates.

This cane has not given such favourable results as others in the experiment plots, probably owing to the fact that it takes long to come to maturity, and so is not fairly judged when reaped at the same time as the other canes under experiment. It is found to give excellent results when grown on estate scale, and is remarkable for the large proportion of juice which it yields, and for its freedom from disease.

The following tables give the latest results that have been obtained with sugar-cane experiments in the Leeward Islands:—

TABLE I.

ANTIGUA.—PLANT CANES.

Means deduced from 16 Plots of each variety of Cane.

No.	Name of Cane.	CANE.	JUICE.		SUCROSE.	
		Tons per acre.	Gallons per acre.	Gallons per ton.	Pounds per gallon of Juice.	Pounds per acre in Juice.
1	Sealy Seedling... ...	28·4	3,246	114·3	2·015	6,542
2	D. 625*	27·9	3,076	110·3	1·902	5,848
3	B. 208	22·7	2,537	111·8	2·284	5,794
4	B. 156	23·8	2,774	116·5	2·082	5,775
5	B. 306	23·1	2,727	118·0	2·091	5,703
6	D. 130	24·6	2,877	117·0	1·977	5,688
7	D. 109	25·1	2,777	110·6	2·003	5,562
8	Red Ribbon	23·6	2,640	111·9	2·097	5,536
9	B. 376†	23·8	2,582	108·5	2·113	5,455
10	Mont Blanc**	24·5	2,630	107·3	2·067	5,437
11	D. 116	23·3	2,631	112·9	1·988	5,230
12	White Transparent ...	22·0	2,481	112·8	2·104	5,221
13	D. 95	21·2	2,331	110·0	2·196	5,119
14	Burke	23·1	2,512	108·8	1·984	4,984
15	B. 109	21·7	2,477	114·2	1·994	4,940
16	D. 74†	21·5	2,499	116·2	1·971	4,925
17	B. 147**...	22·2	2,402	108·2	2·046	4,914
18	B. 393	19·4	2,243	115·6	2·181	4,889
19	D. 115**...	22·6	2,408	106·3	1·945	4,674
20	D. 99	19·8	2,201	111·2	1·952	4,295

* Mean of 12 plots only.
† ,, ,, 14 ,, ,,
** ,, ,, 15 ,, ,,

Table II.

ANTIGUA.—PLANT CANES.

Means for six years.

No.	Name of Cane.	No. of plots grown.	Mean of sucrose in pounds per acre for six years.
1	B. 208	88	7,956
2	B. 156	88	7,661
3	Sealy Seedling	88	7,628
4	B. 306	89	7,244
5	B. 109	87	6,942
6	D. 95	87	6,858
7	D. 130	88	6,687
8	D. 74	88	6,601
9	Mont Blanc	88	6,443
10	White Transparent	88	6,259
11	Red Ribbon	87	6,177
12	D. 116	90	6,093
13	Burke	89	6,091
14	D. 115	88	5,675
15	B. 147	85	5,594

TABLE III.

ANTIGUA.—RATOON CANES.

Means deduced from 14 Plots of each variety of Cane.

No.	Name of Cane.	CANE. Tons per acre.	JUICE. Gallons per acre.	JUICE. Gallons per ton.	SUCROSE. Pounds per gallon of Juice.	SUCROSE. Pounds per acre in Juice.
1	B. 156‡	17·8	1,994	112·0	2·058	4,103
2	T. 211*	15·5	1,739	112·2	2·298	3,997
3	Sealy Seedling... ...	17·9	1,975	110·4	2·023	3,996
4	B. 376	14·7	1,605	109·2	2·098	3,367
5	D. 625**...	15·8	1,781	112·7	1·878	3,345
6	B. 147**...	16·6	1,692	101·9	1·916	3,242
7	D. 109	13·7	1,496	109·2	2·081	3,113
8	Mont Blanc	14·0	1,447	103·3	2·084	3,016
9	Burke	13·3	1,469	110·5	2·044	3,002
10	D. 95†	13·5	1,398	103·6	2·127	2,974
11	B. 306‡	12·0	1,480	123·3	1·960	2,900
12	White Transparent‡ ...	12·1	1,326	109·6	2·144	2,843
13	Queensland Creole† ...	12·8	1,354	105·8	2·042	2,765
14	D. 99†	12·4	1,309	105·6	2·106	2,757
15	B. 208‡	11·3	1,215	107·5	2·253	2,737
16	D. 116‡	12·0	1,372	114·3	1·963	2,693
17	D. 74‡	12·5	1,328	106·2	1·996	2,651
18	B. 109‡	11·7	1,215	103·8	2·159	2,623
19	D. 130‡	10·8	1,214	112·4	1·972	2,394
20	B. 393***	10·2	1,235	121·1	1·933	2,387
21	Red Ribbon‡	10·1	1,128	111·7	2·075	2,341
22	D. 115†	10·8	1,159	107·3	1·935	2,243

* Mean of 4 plots only.
** ,, ,, 6 ,, ,,
*** Mean of 11 plots only.
† ,, ,, 12 ,, ,,
,, ,, 13 ,,

Table IV.

ANTIGUA.—RATOON CANES.

Means for five years.

No.	Name of Cane.	No. of plots grown.	Means of sucrose in pounds per acre for five years.
1	Sealy Seedling	67	4,296
2	B. 306	64	4,175
3	B. 156	65	4,158
4	D. 95	65	4,018
5	B. 109	64	3,953
6	B. 208	66	3,916
	Mont Blanc	67	3,916
8	B. 147	57	3,706
9	Burke	66	3,607
10	D. 74	66	3,586
11	White Transparent	65	3,562
12	D. 130	63	3,543
13	D. 116	66	3,441
14	D. 115	61	3,282
15	Queensland Creole	65	3,270
16	Red Ribbon	66	2,932

Table V.

ST. KITT'S.—PLANT CANES.

Means deduced from 8 Plots of each variety of Cane.

No.	Name of Cane.	Cane.	Juice.		Sucrose.	
		Tons per acre.	Gallons per acre.	Gallons per ton.	Pounds per gallon of Juice.	Pounds per acre in Juice.
1	B. 208	31·2	4,046	126·5	2·231	8,559
2	D. 116	35·7	4,375	122·6	1·739	7,844
3	Sealy Seedling ...	35·3	4,177	118·4	1·837	7,689
4	D. 130	32·5	3,853	118·6	1·949	7,556
5	D. 109	34·5	4,215	122·2	1·802	7,542
6	Queensland Creole ...	30·5	3,633	119·1	2·009	7,329
7	Mont Blanc*	29·7	3,688	124·2	1·967	7,185
8	D. 74	26·8	3,322	124·0	2·122	7,092
9	White Transparent ...	30·0	3,585	119·5	1·982	7,089
10	Striped Singapore ..	30·6	3,719	121·5	1·900	7,087
11	D. 95	26·3	3,278	124·6	2·156	7,039
12	B. 306	26·0	3,538	136·1	1·983	7,014
13	B. 393	25·9	3,273	126·4	2·074	6,897
14	B. 376	28·7	3,564	124·2	1·942	6,708
15	B. 156*	30·2	3,618	119·8	1·802	6,490
16	Burke*	27·4	3,356	122·5	1·905	6,354
17	B. 254†	26·3	3,149	119·8	1·957	6,104
18	B. 147	23·4	2,931	125·3	1·989	5,829
19	B. 109*	27·3	3,439	126·0	1·636	5,694
20	Rock Hall	24·1	2,940	122·0	1·905	5,627

* Mean of 7 plots only.
† ,, ,, 3 ,, ,,

Table VI.

ST. KITT'S.—PLANT CANES.

Means for 7 years.—Deduced from 53 Plots of each variety of Cane.

No.	Name of Cane.	Mean of sucrose in pounds per acre for seven years.
1	B. 208	8,546
2	D. 116	7,697
3	Mont Blanc*	7,405
4	D. 74	7,311
5	Queensland Creole**	7,125
6	B. 376*	7,054
7	B. 306	7,051
8	White Transparent	6,969
9	B. 393	6,919
10	Striped Singapore††	6,753
11	D. 95	6,730
12	B. 147	6,686
13	B. 254†	6,605
14	B. 109	6,550
15	Rock Hall†††	5,139

* Mean of 50 plots only.
† " " 46 " "
** " " 52 " "
†† Mean of 37 plots only.
††† " " 36 " "

TABLE VII.

ST. KITT'S.—RATOON CANES.

Means deduced from 7 Plots of each variety of Cane.

No.	Name of Cane.	Cane.	Juice.		Sucrose.	
		Tons per acre.	Gallons per acre.	Gallons per ton.	Pounds per gallon of Juice.	Pounds per acre in Juice.
1	B. 208	21·7	2,434	112·2	2·343	5,701
2	D. 116	23·8	2,968	124·8	1·956	5,545
3	Mont Blanc	21·1	2,573	122·0	1·958	5,038
4	D. 74	21·6	2,672	123·7	1·878	5,019
5	Queensland Creole ...	19·2	2,258	117·6	2·063	4,656
6	B. 254	21·1	2,404	114·0	1·893	4,549
7	Striped Singapore ...	19·7	2,291	116·2	1·972	4,526
8	B. 393	17·9	2,181	121·8	1·987	4,334
9	D. 95*	17·0	2,043	120·1	2·109	4,307
10	White Transparent* ...	19·2	2,172	113·2	1·975	4,291
11	B. 147*	18·5	2,178	117·8	1·964	4,279
12	Sealy Seedling* ...	18·9	2,219	112·7	1·841	4,085
13	B. 306	16·2	1,998	123·3	1·986	3,969
14	D. 130*	17·5	1,999	114·2	1·959	3,917
15	B. 376	18·0	2,101	116·7	1·855	3,895
16	B. 109	17·7	2,133	120·5	1·799	3,837
17	Burke	16·7	1,876	112·3	2·018	3,790
18	B. 156	17·1	1,967	115·0	1·757	3,457
19	Rock Hall	15·6	1,850	118·6	1·866	3,453
20	D. 109*	15·7	1,811	115·3	1·880	3,405

* Mean of 6 plots only.

Table VIII.

ST. KITT'S.—RATOON CANES.

Mean for 6 years.—Deduced from 36 Plots of each variety of Cane.

No.	Name of Cane.	Mean of sucrose in pounds per acre for six years.
1	B. 208	6,219
2	D. 74	6,016
3	D. 95	6,002
4	B. 306	5,897
5	D. 116	5,824
6	B. 147	5,783
7	White Transparent	5,612
8	Mont Blanc*	5,441
9	Queensland Creole†	5,220
10	B. 376	5,219
11	B. 109	5,206
12	B. 393	5,132
13	B. 254†	4,941

* Mean of 34 plots only. † Mean of 35 plots only.

The various varieties that have been under experimental cultivation have been critically examined, and the following notes give information as to their respective characters:—

Sealy Seedling. This cane has given good results in the experiments both at Antigua and St. Kitt's. At the former, it has given satisfactory results as plants and also as ratoons, but at St. Kitt's, it has not ratooned well. It is a cane of great vegetative vigour, capable of growing well on rather poor and heavy soils where other canes will not thrive, and it appears to stand drought fairly well. It is to be recommended for cultivation on heavy, clayey soils. This cane mills well, but its juice is not exceptionally rich in sugar.

B. 208. This cane requires good, well-tilled soil with a fair rainfall. It grows freely and is easily established; it ripens quickly and thus offers advantages in cases where the land is required for other crops in a rotation. It yields juice of exceptional richness. In ordinary mills it mills well, but is inclined to be somewhat brittle, and therefore is rather difficult to handle where a Krajewski crusher is used.

D. 625. This is a yellow cane, usually of large size, a vigorous grower but yielding juice which is not exceptionally rich in sugar. The average sucrose content of the juice from plant canes for this season at Antigua was low. It is a cane that is likely to attract the attention of planters and will shortly be introduced into the experiments at St. Kitt's.

B. 156. This is a yellow, erect cane, having light-green leaves. It arrows rather freely. It would appear to be more suitable for the heavy, clayey soils of Antigua than for the light ones of St. Kitt's, thus somewhat resembling the Sealy Seedling. The juice which it yields is not very rich in sucrose.

D. 109. This is a purple cane introduced somewhat recently into these experiments. It has given good results at Antigua both as plants and ratoons. At St. Kitt's, the plant canes were satisfactory, but the ratoons were poor. The juice is of moderate richness in sucrose. Like some of the other canes (notably Sealy Seedling), it would appear that this cane is more suitable for the heavy soils of Antigua than for the light ones of St. Kitt's.

B. 376. This is a short, erect, grey or pink-tinged cane with broad, light-green leaves. It arrows freely. At one time it was thought promising in St. Kitt's, but it has not occupied a prominent position there recently. It ratooned well during the last season at Antigua. The juice is only moderately rich in sucrose. This cane must be classed as one of moderate merit for the Leeward Islands.

B. 306. This is a yellow cane not unlike the Bourbon. It does not arrow excessively. It has given good returns both at Antigua and St. Kitt's as plants and ratoons, though the ratoon canes at both places have, this season, been somewhat below the average. It is a cane worth attention in a moderate degree. The sucrose content of the juice is moderate. Instances

are reported where this cane has become dry and hollow in parts, and there is a suspicion of liability to disease. These points require noticing.

D. 116. This is a yellow, erect cane with very broad, dark-green leaves. It arrows freely. The cane appears well suited to the conditions obtaining at St. Kitt's where it has given good results and where it can be recommended for planting. It appears less suitable for planting in Antigua. The juice is somewhat poor in sucrose.

D. 130 is a dark-green, erect cane with dark-green leaves. It is easily grown and arrows freely. It appears to be of moderate merit only, but might be cautiously tried on a small scale. The juice has a fair sucrose content.

D. 95. This is a dark-purple, erect cane which, when growing, often presents a shabby, unsatisfactory appearance. It therefore frequently happens that when reaped, the yield is in excess of what was anticipated. The sucrose content of the juice of this cane is usually very high, though it is to be observed that this feature has not been conspicuous during the past season in the juice from plant canes. This cane thrives best on somewhat heavy moist land, and it does not stand drought well. It is not well suited for the conditions of St. Kitt's, but in some districts in Antigua it gives very good returns and is being planted in fair quantity.

D. 74 is a pale-green, erect cane with light-green leaves, and is of interest because of the attention which it has attracted in Louisiana. It has given fairly good results under experiment at St. Kitt's, but has not been so successful at Antigua. The juice is of moderate richness.

B. 147. A yellow long-jointed cane inclined to trail, having broad, dark-green leaves. It rarely arrows and is now very extensively planted in St. Kitt's. Its cultivation is also being rapidly extended on the lighter soils in Antigua. It is conspicuous as a disease-resisting cane. Its timely introduction into St. Kitt's saved the situation when the ravages of disease bade fair to ruin the sugar industry. Its juice is of full average richness in sucrose when the canes are fully mature. It is an excellent milling cane, containing a large quantity of juice which it yields very freely. When this cane is being crushed the capacity of the pumps attached to the mills is frequently taxed to the utmost, owing to the great flow of juice.

White Transparent. This cane, which is known locally under many names (Naga B., Caledonian Queen, Rappoe, Mont Blanc, and Jamaica cane are believed to be synonyms), is the variety that is most extensively planted at Antigua, where it was introduced to replace the disease-stricken Bourbon. As it fell a prey to disease at St. Kitt's, its place has there been largely taken by B. 147. It is a grey or pink-tinged cane, somewhat inclined to trail, having broad, dark-green leaves. It arrows freely. The juice is of average richness in sucrose, but at times is inclined to be gummy. It is a somewhat fibrous cane. It is believed that several canes

of greater merit are now at the disposal of planters, and it is anticipated that it will be steadily superseded by other canes at Antigua in a manner similar to that already adopted by the planters in St. Kitt's.

B. 303. This cane, which has only recently been introduced into Antigua, showed a disposition to die out in ratoon canes during this season. This was probably due to the dry weather experienced during the early part of the season; but if this character is confirmed, it will render this cane an undesirable one for planting in this island.

The attempts to raise new seedling canes at Antigua and St. Kitt's have not been successful owing, it is believed, to the dryness of the atmosphere at the time when the canes usually arrow: it is thought that the dryness prevents fertilization and so prevents the production of fertile seed. A number of Antigua seedlings have, however, been raised and a few show promise of being useful canes.

An inquiry has been made into the position at Antigua and at St. Kitt's as regards new varieties of sugar-cane. At the close of 1906 returns were collected from sixty-four estates* in Antigua, showing the acreage under each variety of cane then under cultivation for reaping in 1907. A similar return has now been collected from seventy-five estates, showing the acreage under each variety to be reaped in 1908. A return has also been compiled giving the areas under each variety of cane upon forty-three estates in St. Kitt's, representing practically the entire area at present under cane cultivation in that island.

The history of the introduction of new varieties of canes into Antigua may be divided into two periods: (1) that during which Bourbon was replaced by White Transparent, and (2) that during which a critical search is being made for improved varieties.

The first period may be regarded as having been completed, and we may measure the progress made in the second period by ascertaining what proportion of canes, other than Bourbon and White Transparent, is now being planted.

From the following tables it may be seen that for the crop of 1907, there were 8,879½ acres of canes reaped by sixty-four estates in Antigua. Of this acreage White Transparent (excluding Naga B. and Mont Blanc) was responsible for 6,787 acres, Bourbon for 190 acres, and other varieties for 1,902½ acres. The newer varieties, therefore, occupied 21·4 per cent. of the acreage under cultivation. If the returns for the crop of 1908, for the same estates, are referred to, it is found that the newer varieties occupied 1,128¼ acres out of a total of 8,611½ acres, or 24·1 per cent. The returns for seventy-five estates for this crop of 1908, or practically for the whole of the sugar-crop of Antigua, show that out of 9,811 acres of canes to be reaped, 2,578½ acres or 26·2 per cent. are occupied by newer varieties.

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* In reckoning the number of estates mentioned in these returns, in cases where several estates have been amalgamated under one management, the individual estates have been considered; for example, Gambles (which includes Gambles, The Villa, and McKinnon's) has been reckoned as three.

ANTIGUA.

Returns showing the acreage of canes grown under the different varieties for the crops of 1907 and 1908.

Name of Cane.	Acres of canes grown on 64 estates for reaping in 1907.	Acres of canes grown on 64 estates for reaping in 1908.	Increase.	Decrease.	Acres of cane grown on 11 estates for reaping in 1908.	Total for 75 estates 1908.
B. 147	297	482½	185½	...	27	509½
B. 109	65½	31½	...	34	...	31½
B. 156	8½	24	15½	...	...	24
B. 208	332½	357½	25	...	27	384½
B. 306	125½	57	...	68½	14½	71½
B. 376	1	3½	2½	...	..	3½
D. 95	177½	172¾	...	4¾	122	294¾
D. 109	½	8½	8	...	2½	11
D. 115	2	½	...	1½	...	½
D. 116	½	½	...	...	...	½
D. 625	...	16½	16½	...	7	23½
Sealy Seedling ...	246½	356½	110	..	70	426½
Mont Blanc	137½	122	...	15½	48½	170½
White Transparent...	6,787	6,345¼	...	441¾	747	7,092¼
Bourbon	190	138	...	52	2	140
Naga B.	115	80	...	35	...	80
Uba	20	6	...	14	...	6
Mixed varieties ...	373	445	72	...	92	537
Total	8,879½	8,612½				9,811

ST. KITT'S.

Return of acreage of canes from forty-three estates, for the crop to be reaped in 1908, showing acreage in each variety.

Name of Cane.	Acres of Canes.
B. 147	2,708
White Transparent	2,171
B. 208	2,101
B. 109	207
D. 116	100
D. 115	44
D. 95	38
D. 109	19
D. 74	19
B. 306	20
B. 393	3
Bourbon	21
Mixed varieties	55
Total Acreage of Canes	7,506

In referring to the returns from St. Kitt's one is immediately struck by the relatively larger proportion of the total area under cultivation in the newer varieties of cane, amounting as it does to 5,314 acres out of a total of 7,506 acres, or 71 per cent.

This large percentage for St. Kitt's is due to the fact that the White Transparent cane (introduced from Jamaica and locally known as Jamaica cane), which was intended to replace the disease-affected Bourbon, does not exhibit in St. Kitt's that immunity to disease which it had shown elsewhere. Consequently, a more resistant cane was looked for, and this was found in B. 147—a cane that was first brought to the notice of West Indian cane planters through the agency of the then (1899) newly constituted Imperial Department of Agriculture.

MANURIAL EXPERIMENTS.

The manurial experiments are carried out on small rectangular plots each $\frac{1}{40}$ acre in extent: each experiment being repeated many times. This method of working, which may be regarded as intermediate in character between large-field plots and pot experiments, is believed to be that which is most suitable for solving the problems presented in this branch of work.

The experiments with plant canes which were carried out on uniform lines for six years, and in which each of the thirty-three experiments was repeated fifty-eight times, have now been discontinued. The object of the experiments was to ascertain whether it is desirable to use artificial manures in addition to the methods commonly employed. The results obtained show quite clearly that it is neither necessary nor profitable to use artificial manures for plant canes when moderate amounts of pen manure or its equivalent are used in the preparation of the land for planting.

This negative conclusion applies to the average conditions of the Leeward Islands, and is determined partly by the systematic use of organic manures and partly by the climate and rainfall. The conditions are such that the organic manures used, convey to the soil as much plant food as can be used by the cane plant with the supply of moisture usually afforded by a not too abundant rainfall.

In view of these results great stress is laid on the use of pen manure and of organic manures generally, particularly green dressings. These maintain the humus supply and keep the soil in good condition. Poor soils are usually those deficient in humus.

The manurial experiments with ratoon canes are divided into two series: first the 'old series' in which the experiments are carried out on ratoon canes following the plant cane experiments. In this series, each experiment plot receives a double dose of manure, firstly as plant canes and secondly as ratoons. Any increase in the ratoon crops in this series may be due, either to the action of the manures applied to the ratoon canes, or to the action of the residues of the manures applied to the plant canes.

The results obtained show that nitrogenous manures are profitable and necessary for ratoon canes, and the view is expressed that the most remunerative manure for ratoon canes is nitrogen, which may be given in the form of sulphate of ammonia or nitrate of soda without any other addition.

This manure should be applied early, and in one dose. The quantity which may profitably be used appeared to be from 200 lb. to 300 lb. of sulphate of ammonia, or from 250 lb. to 350 lb. of nitrate of soda. The larger amounts will probably prove more remunerative in those places where the conditions of growth are favourable and the rainfall is fairly large.

Phosphates have not proved remunerative and potash doubtfully so. In these cases it must be remembered that phosphates and potash were applied to both plant and ratoon

canes, so that there can be no question as to there being sufficient time for these manures to become incorporated in the soil in such a manner as to exert their influence on the ratoon canes.

In what is denominated the 'new series' of manurial experiments, the artificial manures have been applied to ratoons following plant canes which received no artificial manures. The work in this series has not been carried on for a sufficiently long period to give positive results and to remove the uncertainties due to irregular seasons.

On the whole, the manures, while increasing the yields, have not proved commercially remunerative. There are, however, indications that, as in the 'old series,' nitrogenous manures will prove remunerative, but it is necessary to carry on the experiments in this series for a longer period before definite results can be stated.

THE CENTRAL SUGAR FACTORY AT ANTIGUA.

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In the course of the proceedings of the fifth Agricultural Conference held at Trinidad in 1905, I was afforded an opportunity of placing on record an account of the Central Sugar Factory then in course of erection at Antigua. The nature of the machinery to be employed was stated, and the co-operative contracts under which the factory is worked were explained. (*West Indian Bulletin*, Vol. VI, p. 60.)

It will be remembered that this factory was erected as a pioneer one, designed to solve the much debated question of whether it is desirable, under the conditions in the Leeward Islands, to abandon the muscovado method of sugar manufacture for the methods of modern factories.

I am now able to state that three crops of sugar have been reaped, and the work of the factory has so far developed that it may be of service to those interested in the movement to have details as to what has been done.

CROPS REAPED AND RESULTS.

In 1905, the amount of sugar produced was 1,634 tons from 15,860 tons of cane. One ton of sugar was therefore obtained from 9·70 tons of cane, or sugar at the rate of 10·3 per cent. of the weight of the cane. The sugar realized an average net price of £12 15*s.* 5*d.* per ton, and the price paid to the original contracting proprietors was 14*s.* 1*d.* per ton of canes.

In the second season, that of 1906, 2,348 tons of sugar were produced from 24,676 tons of canes. These figures work out at 9·52 per cent. of sugar on the weight of cane, or 1 ton of sugar from 10·5 tons of canes. The price paid to the original contracting proprietors for canes was 7*s.* 1*d.*, with a bonus addition of 4*d.*, making in all 7*s.* 5*d.* per ton of canes. Canes were also purchased from outside estates at 9*s.* 3*d.* per ton, and peasants' canes cost 7*s.* 8*d.* per ton. The season was one of drought, and it was difficult to obtain a sufficiency of water for maceration; hence the recovery of sugar from the cane was somewhat poor.

In 1907, 4,230 tons of sugar have been made from 40,782 tons of canes. This gives 10·37 per cent. of the weight of the cane, or a ton of sugar from 9·64 tons of cane. The price paid to the original contracting proprietors for canes was 8*s.* 7½*d.* per ton. To this was added a sum of 1*s.* 4½*d.* per ton to bring the price paid for canes up to 10*s.* before division of profits was made, in accordance with the terms of the contract. On division of profits, a further sum of 2*s.* 3*d.* per ton of canes was paid, making the price paid for canes to original contracting proprietors equal to 12*s.* 3*d.* per ton. The proportion of sugar obtained in relation to the amount of cane must be said to be

satisfactory, although it ought not to be the final word in respect to sugar extraction for this factory.

The average composition of the cane will be discussed later in another paper.* It contained, during the past season, 15·1 per cent. of fibre, and 14·4 per cent. of sucrose.

The season of 1907 was the first in which a full supply of cane was forthcoming, and was also the first in which the factory principle may be regarded as being fairly exemplified in Antigua. The results would appear to be satisfactory. The factory, originally planned for a crop of 3,000 tons of sugar, has turned out 4,230 tons on the average of 1 ton of sugar from 9·64 tons of cane. At an average price of £9 16*s.* per ton of sugar the contracting proprietors received 12*s.* 3*d.* per ton of canes delivered; and have, moreover, an interest in the working of the factory.

The factory now has an assured cane supply calculated to yield about 5,000 tons of sugar in a moderately good season.

FINANCIAL POSITION.

It now becomes necessary to examine the financial position. The original capital of the factory was £40,000. This was, however, insufficient, for the first balance sheet, issued in September 1905, showed a capital expenditure of £45,359 and a sum of £3,383 involved as working capital, making a total of £48,742.

The factory erected contained only two three-roller mills, but it was the intention from the first to put in a Krajewski crusher as soon as capital could be liberated for that purpose.

This crusher was added in time for the crop of 1907 and a material improvement in the mill work resulted.

Further heavy expenditure has been incurred in the last two years in extending the railway. This extension involved the purchase of an additional locomotive. It increased the cane supply and will enable the factory to deliver its sugar at the wharves in St. John's without the troublesome carting which has been necessary up to now. The additional expense is amply justified as it promises to be immediately remunerative. The total length of the railway is now about 9 miles.

It has also been found necessary to make minor additions to the plant in order to accommodate crops in excess of the anticipated quantity. In this connexion, in addition to minor improvements, there have been added: a juice heater,† crystallizer, filter press, and three centrifugals.

The machines, materials, and stores required for these additions have cost about £10,000. Of this, about £3,500 have been already paid by being charged in the annual expenses of

* 'Observations on the work of Sugar-cane Mills and deductions drawn therefrom.' *West Indian Bulletin*, Vol. IX, pp. 85-98

† In the original plant, two juice heaters of a heating surface of 500 square feet each were included, and not two of 1,000 square feet of heating surface each as mentioned in the *West Indian Bulletin*, Vol. VI, p. 62.

working ; £8,800 are added this year to capital account, and the remainder will appear as a charge in future accounts.

We have thus an original capital expenditure of £45,359 and further capital expenditure of about £6,800, making in all £52,159, exclusive of the value of stocks and stores of spare parts.

The last balance-sheet shows total capital of £51,713 10*s*. 1*d*., but of this £8,470 11*s*. 3*d*. is in the form of cash and amounts due.

The net sum of £43,242 18*s*. 10*d*. is therefore left as the charge against the value of machinery. This is £9,917 below its cost, and to this can be added £2,684—the value of 'stocks, stores. and spare parts' on hand on September 30, 1907. A gain, therefore, of £12,601 is shown—an amount that does not include bonuses paid to shareholders and cane growers.

We can, however, obtain a clearer insight into the position of the factory and its gains by dealing with the items shown in the profit and loss accounts for the three years.

The amounts paid off are as follows: The sum of £2,000 has been written off by way of sinking fund in each of the three years, in all £6,000: an amount of about £3,500 has been paid out of annual working charges for extensions. That is to say, some £9,500 have been already paid out of profits towards reducing the capital charges of the factory. In addition, two Government debentures, each of £1,000, have been written off under the contract. These are amortized without payment and cannot be considered as a charge on profits.

In addition to the sums of £9,500 and £2,684 above mentioned, the profits of the factory for equal divisions were in the first year, £3,885 1*s*. 8*d*., and in the third year £6,345 10*s*. 8*d*. In the second year, £331 17*s*. 10*d*. was paid to the original contracting proprietors, there being insufficient for division to make up the price of cane to 10*s*. per ton. To this must be added the sums of about £1,920 required in this season to make up the price paid for original contracting proprietors' canes to 10*s*. per ton,* and also the £2,000 carried to the reserve fund. In all, therefore, the *gross profits* of the factory for the three years of its working may be set down as £26,665, exclusive of interest on share capital but including the value of stores in hand.

DISTRIBUTION OF PROFITS.

The factory being on a co-operative basis, we may inquire into the distribution of these profits.

The original contracting proprietors have actually received in money in the first year £1,942 10*s*. 10*d*., in the second £331 17*s*. 10*d*., and in the third £3,172 15*s*. 4*d*., and £1,920. In

*The profit and loss account shows only a statement of 10*s*. per ton paid for original contracting proprietors' canes. As a matter of fact the payments were made in two stages; 8*s*. 7½*d*. being paid in the fortnightly payments, and 1*s*. 4½*d*. as an additional payment out of profits.

all they received £7,367 4*s.* over and above the sum paid as the value of the canes on the basis of the value of 4½ ℔. of 96° sugar per 100 ℔. of cane. As the original contracting proprietors have, during the three years, delivered 62,274 tons of cane, the cash payments have been equal to 2*s.* 4*d.* per ton of cane, in addition to the payments on the 4½ ℔. basis.

The price actually paid on the 4½ ℔. basis for the 62,274 tons is £28,501 1*s.* 5*d.* or practically 9*s.* per ton, which with the bonus addition of 2*s.* 4*d.* brings the average cash price paid for original contracting proprietors' canes for the three seasons to 11*s.* 4*d.* per ton.

The A shareholders in the meantime have received in the aggregate £5,115 6*s.* 2*d.* in addition to their interest at 5 per cent. per annum.

But each party may be held to participate in those portions of the gross profits that have not been paid out in cash bonuses. An amount of £12,482 (£5,115 + £7,367) has been paid as cash bonuses, and therefore £14,183 of the gross profits are left as having been invested in the factory. It will, however, be seen that no reference has been made to depreciation. During the three years there have been spent for repairs, maintenance, and extensions from current working account in the aggregate £7,187 4*s.* 10*d.*; but of this, £3,500 have been regarded as being on account of extensions and have been treated above. This leaves the sum of about £3,687 as having been spent on repairs and renewals. This may be considered in the nature of expenditure on depreciation account, but should, however, be held to be an insufficient amount.

Having regard to the conditions of the factory, and taking into account the manner in which repairs have been made, I think it will be ample to charge 5 per cent. on £50,000 for depreciation, that is to say, £2,500 a year or £7,500 for the three years. This sum may therefore be deducted from the £14,183 regarded as profits invested in the factory.

The sum of £6,683 is left therefore, as profits invested in the factory after allowing for depreciation, and this sum may be regarded as belonging in equal moieties to the A shareholders and the original contracting proprietors, or £3,341 to each party, or rather at the rate of 1*s.* 0¾*d.* per ton of cane supplied.

CONCLUSION.

The position of the original contracting proprietors may be summed up in saying that they have sold 62,274 tons of canes and have received £28,501, or 9*s.* per ton, by way of first payment; £7,367, or 2*s.* 4*d.* per ton, by way of cash bonuses, and have invested £3,341, or 1*s.* 0¾*d.* per ton of cane in the factory.

The A shareholders have received 5 per cent. interest on their money and, in addition, cash bonuses of £5,115 equal to 6·8 per cent. per annum on the capital invested by them. They have therefore received 11·8 per cent. per annum in all, and in addition there is the investment in the factory

of £3,341 out of profits, equal to a further 4·4 per cent. per annum.

It may be added that the factory has made, during the three years, 8,214 tons of sugar, which realized £81,682, or, on the average, £9 18*s*. 10½*d*. per ton.

It is interesting to note that, calculating the value of canes, on the basis of 4½ lb. of 96° sugar per 100 lb. of canes on this price, it will be found that canes were worth 8*s*. 11½*d*., a figure practically identical with the actual price paid by way of first payment. It is also worth noting that, if 9*s*. per ton of cane is the equivalent of 4½ lb. sugar per 100 lb. of cane, the cash bonus addition of 2*s*. 4*d*. is equal to a further 1⅙ lb., or 11*s*. 4*d*. is equal to 5⅔ lb. of 96° sugar per 100 lb. of cane.

While it is hoped, and anticipated, that future years' working may show even more favourable results, it must be remembered that the large interest on working capital is in a measure due to the fact that a portion of the capital invested bears no interest.

These figures, I think, indicate a very sound financial position, and should prove useful to those who contemplate erecting similar factories.

DISCUSSION.

Hon. F. M. ALLEYNE (Barbados) enquired what it cost per mile to provide the railway lines belonging to the factory.

Dr. WATTS replied that the lines, including rolling stock, cost about £100 per mile.

Hon. F. J. CLARKE (Barbados) asked whether there were many outside the original contractors who sent their canes to the factory, and at what rate were they paid.

Dr. WATTS replied that there were many estates which now sold their canes on a basis of 5½ lb. of sugar per 100 lb. of canes, which worked out at a little under 11*s*. 4*d*. per ton, and they were perfectly satisfied to sell their canes at that rate.

Mr. T. W. B. O'NEAL (Barbados) enquired whether the factory was a government one.

Dr. WATTS replied that it was a co-operative concern. The Government gave the residue of the Imperial Grant-in-Aid to assist in the establishment of a central factory, and that remains as a lien against the factory. They were under the obligation, however, to purchase not less than a certain quantity of canes every year from the growers at not less than 7*s* 6*d*. per ton.

The PRESIDENT stated that out of 6,000 tons of crystals shipped from Antigua, nearly 2,250 tons represented the gain due to improved methods of crushing and manufacture. He made that statement on the basis of information given him by Dr. Watts, and he should like Dr. Watts to give some explanation in connexion with it for the benefit of the Conference.

Dr. WATTS said that the relationship between the muscovado sugar industry and the sugar produced by the

factory still remained an unsolved problem for the reason that they had never yet been able to get an adequate series of the weighing of canes for the whole of a crop on any muscovado estate. Every cane that went to the factory was weighed and paid for. Last year they got some figures from a muscovado estate which showed that it took 17 tons of canes to make 1 ton of sugar, while the factory took 9·6 tons of canes to make a ton of sugar. Allowing therefore a sufficient margin on either side, they might for purposes of calculation assume that whereas the factory might take 10 tons of canes to make a ton of sugar, the muscovado mills would take at least 16 tons.

Hon. F. J. CLARKE said that the conditions must be vastly different in Antigua from what they were at Barbados, because three years ago when the figures in connexion with the Antigua factory were published, some of the planters in Barbados took the trouble to weigh their canes, go into calculations and make comparisons with the figures of the Antigua factory. They found that with their muscovado process they did very much better than that factory and had realized fully 14s. a ton for canes. He had been furnished with statistics by several planters who weighed their canes, and in every case they had found that they would have lost considerably by selling their canes to a factory at the prices paid at Antigua.

Dr. WATTS was of opinion that for the planter to get full value for his canes the factory must be worked on the co-operative principle.

The PRESIDENT pointed out that this point was specially emphasized in the Report of the Royal Commission, and until they could get a co-operative factory working in Barbados and owned by the people themselves, there was little chance of the aspect of things being materially altered.

Mr. G. ELLIOTT SEALY (Barbados) asked whether Dr. Watts was in a position to inform them what was the difference in the cost per ton of sugar or per acre of working estates in Antigua now that the canes were sent to the central factory.

Dr. WATTS said that was a question which one could not answer. It was a matter which concerned an individual so closely that it was not always prudent to ask too much as to what profit he was making out of his estate. He had never asked such a question of any planter, nor had he ever been supplied with information that would enable him to answer the question whether the clearance per ton of canes on a plantation manufacturing its own sugar was greater or less than that on a plantation selling its canes to the factory. He thought he could venture to say, however, that the saving on a plantation supplying its canes to the factory was greater than was anticipated.

Hon. B. HOWELL JONES asked whether the canes should not be paid for by contents rather than by weight, as the sugar-content of the juice of the sugar-cane varied considerably.

Dr. WATTS thought that so far, satisfaction was felt as to buying canes by their weight.

OBSERVATIONS ON THE WORK OF SUGAR-CANE MILLS, AND DEDUCTIONS TO BE DRAWN THEREFROM.

BY FRANCIS WATTS, C.M.G., D.Sc., F.I.C., F.C.S.,
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There have been numerous discussions as to the best means of ascertaining and stating the work done by a mill in crushing canes. The practice of stating the work in terms of percentage of juice obtained is obviously unsatisfactory and valueless, for the amount of juice expressed will depend as much upon the quantity of juice present in the canes as upon the efficiency of the mill, as canes containing 10 per cent. of fibre will naturally give much more juice than canes containing 15 per cent.

It has been proposed to state the efficiency of sugar mills in terms of the moisture in the megass. This may be a fairly useful method in cases where maceration is not employed, but in modern factories, maceration is commonly adopted, and the amount of moisture left in the megass becomes of far less importance than the amount of sugar remaining. During the process of maceration, the sugar is washed out, and the residual megass retains some of the maceration water, and, therefore, the moisture, as shown by analysis, is excessive. Moreover, owing to the varying composition of the canes, it is not satisfactory to base the comparison on the sugar remaining in the megass.

Nowhere has this question excited greater interest than in connexion with the Central Sugar Factory at Gunthorpe's, Antigua, for it is desired to obtain from the working of this factory data for comparing the efficiency of modern with that of old methods, and for advising as to the desirability of making further changes.

The varying character of the canes in different districts and in different seasons has made it possible to obtain a large amount of information, but much of this is of the most contradictory character and therefore greatly complicates the position.

As the result of discussions, Mr. J. Lely, Chemist to the Gunthorpe's factory, has made the suggestion that the efficiency of a mill may be accurately measured by ascertaining the proportion of juice remaining in the megass in relation to the fibre; in other words, the quantity of first mill juice per 100 parts of fibre. This figure is obtained by determining the percentages of fibre and sucrose in the megass. The sucrose is calculated into terms of first mill juice, and the amount of this, per 100 parts of fibre, ascertained.* The formula employed is as follows:—

$$\left\{\begin{array}{l}\text{Normal juice in}\\ \text{megass per 100 fibre}\end{array}\right. = \frac{\text{per cent. sucrose in megass} \times 100 \times 100}{\text{per cent. sucrose in first mill juice} \times \text{per cent. fibre in megass}}$$

* This factor is different from the one sometimes used, showing the amount of diluted juice per 100 parts of fibre.

This factor permits of the comparison of mills working under the most diverse conditions, either of the quality of the cane or juice, or of the character of the mills. Comparisons can be made between mills grinding either good or indifferent canes: it is immaterial whether maceration is used in one of the mills under comparison and not in the other—it even applies to such methods as the Naudet process wherein the megass is discharged, saturated with water. A direct comparison can also be made between any mill and the Naudet process irrespective of the quality of cane handled by each. Similarly, a single mill in a muscovado sugar works may be directly compared with a modern mill using maceration. It is of no consequence what quality of cane either mill deals with.

From the data available, the first mill juice remaining in megass per 100 parts of fibre has been calculated for the whole of the period during which Gunthorpe's factory has been working, for the average of ninety-six Java mills in 1906, on the basis of the data given in the *International Sugar Journal*, Vol. ix, p. 387, and also for five Government mills in Queensland for 1906 and 1907 from data furnished in Reports of the Comptroller. These are as follows:—

TABLE I.

FACTORY AND YEAR.	First mill juice per 100 parts of fibre in megass.	Maceration water used, per cent.
Gunthorpe's, Antigua, 1905	92·2	13·4
„ „ 1906	103·2	9·1
„ „ 1907	80·4	21·1
Java, average of ninety-six mills, 1906	62·7	14·0
Queensland, Proserpine mill, 1906 ...	62·2	35·8
„ 1907 ...	65·1	...
„ Pleystowe „ 1906 ...	53·4	35·0
„ Gin Gin „ 1906 ...	94·3	10·9
„ 1907 ...	80·7	...
„ Mt. Bauple „ 1906 ...	87·7	26·7
„ 1907 ...	68·7	...
„ Moreton „ 1906 ...	77·0	16·6
„ Netang River 1907 ...	78·2	...

These figures afford an accurate basis for comparison of the work of the several mills irrespective of the kind of cane dealt with by each. It is immaterial what was the sucrose or fibre content of the canes.

Such figures as these cannot fail to be of interest and value to mill owners. From them it is gathered that the work of 1907 at Gunthorpe's was much more efficient than that of the two previous years, but even this was not so good as the average work done by mills in Java. When compared with the Queensland work, it is seen to be inferior to that of three of the mills but better than that of two.

As Gunthorpe's mill lost 80·4 parts of juice per 100 parts of fibre, while the Java mills lost 62·7, a difference of 17·7, and, as canes in Antigua contain 15 per cent. of fibre, it follows that Gunthorpe's mill would be required to give 2·9 parts more juice per 100 parts of cane to ensure its work being up to the Java average. Such rapid and direct comparisons as this have not hitherto been possible.

The question naturally occurs—What is the position with regard to the small mills employed in the muscovado industry of the West Indies? Attempts were made to answer this question, but unexpected difficulties arose.

In the first place, muscovado mills are situated at some distance from any chemical laboratory. It is, therefore, difficult to procure megass in an unaltered condition, well sampled, and fit for analysis. This difficulty may be got over by drying the megass immediately after it leaves the mill, for dried megass serves as well as fresh megass for the determination of first mill juice per 100 parts of fibre, seeing that this depends on the ratio between the sucrose and the fibre, and is independent of the moisture. The means of drying megass were not perfected when the season closed.

But even if this difficulty be overcome, there remains a much more serious one. It was found that the work done by a single mill varied enormously in character, according to the manner in which the canes are fed into the mill. With irregular feeding and low pressure of steam on the engine, the work is very poor: while with a full, even feed and high pressure of steam on the engine, the work is often surprisingly good. Taking samples of megass at a muscovado mill is an unusual operation, for which special preparation generally has to be made. Consequently, considerable attention is directed to the operation. Care is usually taken that there is full pressure of steam, a good supply of cane on hand, and that the feeding is as perfect as can be managed. As a result, the work done during a few minutes bears little relationship to the average daily work and is likely to be most misleading.

Efforts will be made next season to obtain average and representative samples of megass from muscovado works, but the problem presents considerable difficulty.

A certain number of results have been obtained during the past season and these are placed on record here, with the

remark that they are subject to the limitations just referred to :—

TABLE II.

MUSCOVADO MILLS.

Mill.	First mill juice per 100 parts of fibre in megass.	Remarks.
A. 1st trial ...	113	Hydraulic attachment to mill.
„ 2nd trial ...	135	
B.	172	
C.	158	
D. 1st trial ...	174	
„ 2nd trial ...	172	
„ 3rd trial ...	165	
E. 1st trial ...	133	
„ 2nd trial ...	129	
„ 3rd trial ...	121	
„ 4th trial ...	132	
„ 5th trial ...	134	Five samples taken during day and bulked.
F.	181	
G.	125	Hydraulic attachment to mill.

With cane of the kind grown at Antigua on the average of the whole season's work, crushing of 50 per cent. of juice on the weight of the cane would give about 200 as the factor for first mill juice in megass per 100 parts of fibre, while with 55 per cent. crushing, the factor would be about 166, and with 60 per cent. crushing, about 133.

Although the investigation at the present stage has not yielded such figures as may be taken as satisfactorily setting out the average work done by the single muscovado mills, it has shown what is of some importance; namely, that the work of single mills is very variable and that the average work done from day to day may be considerably improved by careful supervision and working.

An attempt was made to study the work done by Bendal's mill. This consists of a powerful three-roller mill preceded by

a McNiel's cane shredder. The engine is unusually powerful, being intended to drive another mill in addition to the present plant. Steam is supplied from Babcock and Wilcox boilers at a steady pressure of 80 ℔. per square inch. The investigation presented considerable difficulty, owing to the distance from the laboratory and the want of means of drying the megass. As the mean of a large number of analyses, it was found that the normal juice per 100 parts of fibre ranged from 140 to 120, and averaged 131. Considerable pains were taken to obtain samples of megass representing the ordinary daily work, i.e., representing the average crushing.

The figures are therefore instructive for comparison with the results from single muscovado mills. They justify the conclusion that many of the results from these latter mills are unusually good, indicating what they can do under favourable conditions rather than what they actually do from day to day.

The factor, normal juice per 100 parts of fibre, may be used to calculate the probable losses or gains resulting from the use of various mills; thus the work at Gunthorpe's might perhaps be brought up to the excellence of the mills in Java or Queensland—up to a factor of 60 instead of 80. Now, as will be shown later, the average canes of Antigua throughout a season contain .15 per cent. of fibre, and therefore the gain would be $\frac{20 \times 15}{100} = 3{\cdot}0$ parts of juice per 100 parts of cane.

The Gunthorpe's returns show that 1 ton of sugar requires 1,338 gallons or 6·46 tons of juice. With a crop of 40,000 tons of cane, therefore, the increased output of juice would be 1,200 tons, equal to 185 tons of sugar, which would have an approximate value of £1,850.

We thus have a means of ascertaining how much a given improvement is worth, and whether, from a business point of view, it is desirable to seek to attain it.

COMPOSITION OF SUGAR-CANE.

In making computations concerning the sugar industry of a given district, it is of great use to know the quality and composition of the cane dealt with. In Antigua and many other places, this has hitherto presented very considerable difficulty. Information obtained from the analysis of samples of cane is liable to be utterly untrustworthy and misleading, and it is impossible to take samples of canes which satisfactorily represent the average of a large bulk even to an approximate degree of accuracy.

Something may be done by taking large samples and crushing them in small mills (larger than laboratory hand-mills), and analysing the juice and the megass, but even in this method it is difficult to obtain results fairly representative of a season's cane supply.

The returns of a factory under adequate chemical control enable us, however, to calculate with considerable accuracy* the average composition of the canes handled. The total amount of sugar in the juice is accurately known, and that in the megass is calculated from analyses: the amount of fibre in the megass is also readily ascertained by analysis.

In this connexion, it has been noted that the megass obtained from mills where maceration is employed contains some excess of water over and above what would be present if dry crushing were employed. Attempts have been made to investigate this point. In this inquiry, it seemed reasonable and admissible to calculate the amount of juice remaining in the megass, to ascertain the amount of water contained in this juice, and, after deducting this water from the total water present, to refer to the excess as 'water other than juice.' Any abnormal quantity of this water other than juice would be held to be maceration water which had not been crushed out of the megass.

The idea of canes containing 'water other than juice' is a legitimate and useful one, for the fibro-vascular bundles and the cell walls contain water and little or no sugar. This water is found and estimated in the processes of analysis, but has no relation to the sugar-containing juice.

It now becomes necessary to ascertain how much 'water other than juice' naturally occurs in megass when crushed without maceration. Only a few reliable analyses are available. On three occasions, the megass at Gunthorpe's was examined when no maceration was being used, and it was found that the 'water other than juice' amounted to (a) 25·87, (b) 37·25, and (c) 33·07 per 100 parts of fibre, the mean being 32·06. As the juice in these analyses was first mill juice and not average juice, the 'water other than juice' so found would be rather too high, probably by about 2 per cent. It is concluded, therefore, that the normal amount in thoroughly crushed megass under dry crushing is about 30 per 100 parts of fibre.†

The mean results for the season 1907 at Gunthorpe's factory show that the megass contained, as the average of the season's work, 43·08 parts of 'water other than juice' per 100 parts of fibre. This amount is held to be above the normal for dry crushed megass, and the assumption is made that this excess is about 11·5 per 100 parts of fibre, or 5 per cent. on the weight

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* Sucrose per 100 parts of cane =

$$\frac{\text{Total sucrose in diluted juice} \times 100}{\text{Total weight of cane}} + \frac{\text{Per cent. sucrose in megass} \times \text{megass per 100 parts of cane}}{100}$$

† These results are in some measure confirmed by the examination of samples of cane crushed in a hand-mill. One set of experiments gave (1) 26·08, (2) 27·96, (3) 26·75 ; mean 26·93. Another series gave (1) 30·93, (2) 31·79, (3) 35·08 ; mean 32·6 per 100 parts of fibre.

of the megass as analysed. It is admitted that this is but an approximation, but it is believed to be not far from the truth.*

If this approximation is accepted, it follows that the analyses of the megass as recorded do not correctly represent the composition of the true megass, for the megass as analysed consists of 95 parts of true megass and 5 parts of water. It becomes necessary therefore, to recalculate the composition of the megass on this basis.

Following these lines the megass at Gunthorpe's stands as follows:—

	A, as analysed.	B, corrected for excess of water.
Water	47·41	44·64
Sucrose	6·48	6·82
Fibre	43·52	45·81
Undetermined ...	2·59	2·73
	100·00	100·00

If now we accept these figures, it is possible to calculate the average composition of the canes dealt with at Gunthorpe's factory. The results are as follows:—

	1905.	1906.	1907.
Sucrose per 100 parts of cane	15·25	14·18	14·39
Fibre " " " " "	15·05	15·20	15·07

The sucrose has varied slightly from season to season, but the fibre has been remarkably uniform.

From the data available the composition of the cane may be stated in relation to the mill work thus:—

* The examination of the figures available in the case of the ninety-six factories in Java already referred to, goes to show that the megass from these mills contains an excess of water, and should be subject to correction on the lines given above:—

Mills.	Average juice in megass.	Total water in megass.	Water in juice in megass.	Water other than juice in megass.	
				Per cent.	Per 100 parts of fibre.
Java. Average of ninety-six mills. 1906.	30·5	47·1	25·1	22·0	47·6
Antigua, Gunthorpe's ...	36·2	47·4	28·7	18·7	43·6

Composition of cane.	1905.	1906.	1907.
Average juice expressed	65·1	64·2	67·1
Average juice left in megass ..	15·5	16·1	12·5
Water other than juice in megass	4·3	4·4	4·8
Fibre	15·1	15·2	15·1
Total	100·0	99·9	99·5

Other interesting information can be deduced. This may be grouped as follows:—

	1905.	1906.	1907.
Average juice in 100 parts cane ...	80·6	80·3	79·6
„ „ expressed by mill per 100 parts of juice present... ...	80·8	80·0	84·3
Average juice lost in megass per 100 parts of juice present... ...	19·2	20·0	15·7
Sucrose in juice per 100 parts of sucrose in cane	81·7	80·8	84·4

These figures are very instructive as showing the character of the cane met with in Antigua, over a large area, and in three successive seasons. They show how much sugar such canes may reasonably be expected to yield under different systems of manufacture, and indicate what 'crushing' may be expected; effectually disposing of the idea that under any system of dry crushing anything like 72-5 per cent. of juice is attainable. Even with maceration the maximum obtainable with a cane shredder, double mills, and moderate maceration, would appear to approximate 70 per cent. Small muscovado mills may be expected to show 'crushings' of about 50-5 per cent. as the average of a whole season, when dealing with cane of this type, having regard to the nature of the mill work under average conditions of steam pressure and mill feeding.

It may be interesting to add, for comparison, the following information relative to composition of canes in Java:—

Per 100 parts of cane.	Java (96 mills).	Queensland.				
		Proserpine.	Pleystowe.	Gin Gin.	Mt. Bauple.	Moreton.
Sucrose ...	12·4	12·9	14·5	12·1	13·8	12·5
Fibre ...	11·5	11·8	11·5	10·6	11·5	10·7

In factories employing maceration some difficulty is usually experienced in ascertaining the amount of juice expressed from the cane, for it seldom happens that accurate means exist for measuring the amount of maceration water used. The use of water-meters suggests itself, but these are often unreliable in their indications and require to be constantly checked.

It may be that the correction for excess of water in megass will not be accepted by some without question. The foregoing results have therefore been recalculated without the correction, the sucrose and fibre in this case being termed 'apparent':—

Average composition of cane.	1905.	1906.	1907.
Juice expressed	65·1	64·2	67·1
Juice left in megass	14·1	15·3	11·9
Water other than juice in megass ..	5·9	6·1	6·2
Fibre	14·3	14·4	14·3
Total	100·0	100·0	100·0
Juice in 100 parts of cane	79·8	79·5	79·0
Juice expressed by mill per 100 parts juice present	81·6	80·8	84·8
Juice lost in megass per 100 parts juice present	18·4	19·2	15·2
Sucrose in juice per 100 parts apparent sucrose in cane ..	82·5	80·7	85·1

ESTIMATION OF JUICE.

After careful consideration, the following conventional manner of estimating the amount of juice has been adopted at Gunthorpe's. The amount of juice contained in the total diluted juice is calculated, on the assumption that the average juice expressed from the canes would have the specific gravity (or total solids) of the first mill juice, but would have the purity of the total diluted juice. The juice so found is referred to as 'whole' juice.* The calculated composition of the first mill juice and the 'whole' juice at Gunthorpe's during the season 1907 was as follows:—

	First mill juice per cent.	'Whole' juice** per cent.
Sucrose†	18·51	17·96
Glucose	0·93	0·88
Non-Sugar	1·14	1·74
Total Solids ...	20·58	20·58
Glucose Ratio	5·05	4·88
Purity	89·09	87·03
(† lb. per gallon	2·002	1·942)

This assumption of the idea of 'whole' juice appears to be a useful one and, although only an assumption, it is very close to the truth. It may be contended by some that the residual juice, as we approach the end of the crushing and as left in the megass, will have a lower specific gravity than that expressed in the earlier stages of crushing. It will have a lower sugar content and lower purity, the amount of total solids not falling off so rapidly as the sucrose, so that there is not likely to be a great difference in the specific gravity.

There appears to be but a small amount of information available in order to settle the question as to the specific gravity of the residual juice. Some years ago, the megass from a small Chatanooga mill was submitted to pressure in a hydraulic press. This mill expressed about 65 per cent. of the weight of the cane in the form of juice, and the hydraulic press (which was of considerable power) expressed a further quantity of about 6 per cent.†† The specific gravity of the mill

* Weight 'whole' juice $= \dfrac{\text{Weight diluted juice} \times \text{Brix 1st mill juice}}{\text{Brix diluted juice}}$

** If desired, the figures so obtained may be used to convert the expression 1st mill juice per 100 parts of fibre into 'whole' juice per 100 parts of fibre by multiplying by $\dfrac{\text{sucrose in 1st mill juice}}{\text{sucrose in 'whole' juice}}$ when we find, for example, that 80·4 parts of first mill juice per 100 parts of fibre, as obtained at Gunthorpe's in 1907, are equivalent to 82·9 parts of 'average' juice.

†† See (1) Supplement to *Leeward Islands Gazette*, August 27, 1896, and (2) *Report* on the results obtained on the Experimental Fields at Skerrett's, Antigua, 1897.

juice and the press juice was noted amongst other points. On referring to these figures, it is found that the average specific gravity of fifty samples of mill juice was 1·07047, while the average specific gravity of the press juice was 1·06773—a difference of ·0037. Now, as the mill juice was about ten times the quantity of the press juice, the lowering of the average gravity by the admixture of the residual (press) juice, would be almost negligible in ordinary factory calculations.

This convention is here adopted and is recommended for use in making comparisons of the kind dealt with herein.

It may be pointed out that attempts to ascertain the amount of juice by weighing the megass and deducting the weight from the weight of cane are futile, seeing that where maceration is employed the weight of the megass will be some 5 per cent. above the true weight in consequence of its retaining some maceration water.

It may again be stated that comparisons of mill work on the basis of first mill juice retained in the megass, per 100 parts of fibre, are free from all these uncertainties ; the only difficulty being that of obtaining representative samples of megass—a difficulty not very great in large factories but very great under the condition of the muscovado industry.

CONCLUSION.

In endeavouring to introduce changes and improvements based on successes elsewhere, it is all-important to have means of comparing the work done under very diverse conditions, conditions so diverse perhaps that direct comparison seems impossible. The above results are put forward in an attempt to find a common basis of comparison for the sugar work in various parts of the world, and in the hope that others may furnish data whereby these comparisons may be made and published.

For the local data upon which the conclusions drawn in this paper are based, I am indebted to the reports of Mr. J. Lely, Chemist to Gunthorpe's Sugar Factory, for information as to matters pertaining to that factory, and to Mr. H. A. Tempany for the analytical work relating to megass from steam mills.

APPENDIX I.

The following data relative to the work at Gunthorpe's factory may be of interest in connexion with the foregoing figures:—

QUANTITY OF SUGAR.

	1907.	1906.	1905.
Tons cane crushed	40,782	24,425	15,860
Tons 96° sugar made ...	4,235	2,296	1,600
Tons 2nd „ „ ...	—	52	35
Tons cane per ton of sugar...	9·62	10·44	9·70
Gallons diluted juice ...	7,017,660	3,560,940	2,437,500

COMPOSITION OF FIRST MILL JUICE.

	1907.	1906.	1905.
Total solids, per cent. ...	20·58	20·10	21·46
Sucrose... „ „ ...	18·51	18·33	19·69
Glucose... „ „ ...	0·93	—	—
Purity ... „ „ ..	89·9	91·2	91·7
Glucose Ratio...	5·1	—	—

COMPOSITION OF DILUTED JUICE.

	1907.	1906.	1905.
Total solids, per cent.	17·00	18·43	18·93
Sucrose... „ „	14·84	16·31	16·89
Glucose... „ „	0·72	—	—
Purity ... „ „	87·3	88·5	89·2
Glucose Ratio	4·9	—	—

COMPOSITION OF MEGASS.

	1907.	1906.	1905.
Water, per cent. ...	47·41	49·9	49·5
Sucrose „ „ ...	6·48	7·6	7·6
Fibre „ „ ...	43·52	40·1	41·1
Maceration water used per cent. on juice by weight	21·1	9·1	13·4

APPENDIX II.

NOTES ON SAMPLING AND ANALYSING MEGASS.

Sampling.—Although megass admits of more perfect sampling than cane, it presents difficulties which are only fully appreciated when attempts are made to conduct rigidly accurate work with this material.

Difficulty arises first from the irregular working of the mills. In order to ensure the collection of samples fairly representative of the average, the samples should be taken at frequent intervals, and they must be fairly large in bulk.

Further difficulty arises from the irregularity of the material, particularly where only single mills exist; the megass often consists of large pieces mixed with smaller ones and is exceedingly difficult to sample. In these cases rather large samples must be taken in order to obtain reliable results.

In practice, it will be found convenient to take samples at regular intervals, such as every hour or half hour, then to dry them, and finally to reduce the samples to a convenient size after cutting up all pieces, or what is better, grinding to coarse powder in a mill, and carefully mixing. If this can be done

reliable samples of megass may be obtained, and the work is not of a haphazard character.

If it is desired to know the amount of moisture in the megass, it will be convenient to take a fixed weight, such as 500 or 1,000 grammes, weighed with reasonable accuracy, at each sampling. After drying, the weight of the aggregate sample is taken and the loss of moisture is determined. When it is desired to ascertain only the first mill juice per 100 parts of fibre, it is not necessary to determine the amount of moisture.

In this manner samples of megass may be procured which may be kept without change and may be readily transported from the mill to the laboratory even when they are a considerable distance apart.

The drier is most conveniently heated by steam. For this purpose a small coil (which can readily be constructed at any sugar factory out of ¾-inch iron pipe), is placed at the bottom of a shallow wooden box—(which admits of being wholly, or partially closed,)—and is connected with the factory steam supply. The drying chamber should be well ventilated in order to permit of rapid drying, and care must be taken to see that the drier is working with such efficiency as to prevent the loss of sugar from the fermentation of the megass. Any loss of sucrose leads to results which erroneously indicate better mill work than is actually being obtained. It must, therefore, most carefully be guarded against.

In many muscovado boiling houses, the boiler is not covered, and its surface affords a supply of heat which may be used conveniently for drying megass. A box fitting the curve of the boiler and furnished with a bottom of canvas or linen raised an inch or two above the boiler will make a good drier.

At the time when each sample of megass is taken a measured quantity of juice from the mill * is placed in a bottle containing a preservative. The preservative may be carbolic acid and a small quantity of dry lime, or corrosive sublimate. The aggregate sample of juice will correspond with the aggregate sample of megass, and will serve for the determination of sucrose in the first mill juice and for the calculation of the first mill juice per 100 parts of fibre.

ANALYSING.—The methods of analysis of megass are given in the various text-books dealing with sugar house work. Amongst these may be mentioned Prinsen Geerligs' *Methods of Chemical Control in Cane Sugar Factories*, but it is thought that one or two notes may not, however, be out of place here:—

Moisture.—This is determined by drying a known weight at 100°C. to constant weight; this is usually effected in five hours.

Fibre.—This may be ascertained with sufficient accuracy by calculating, after the manner described by Geerligs, by deducting the weight of the 'total solids' proper to the juice in the megass from the weight of the dry matter in the megass, the difference being fibre. The 'total solids' are ascertained by calculation on the basis of the purity of the last mill juice.

* From the shredder and first mill where there are several mills, and before any maceration water is mixed with the juice.

The purity of the last mill juice will range from 78 to 80 in different countries according to the character of the cane. In Antigua it has usually been taken as about 80.

The calculation is best illustrated by an example :—

Dry substance in megass	60·0
Sucrose in megass	7·0
Purity of last mill juice	80·0

The 'total solids' of the juice equivalent to the sucrose are $\frac{7·0 \times 100}{80} = 8·75$. Then the fibre is $60 - 8·75 = 51·25$.

Sucrose.—(a) Beaker method. Twenty grammes of megass are put in a tared tin cylinder, weighed again and moistened with 300 grammes of water and 3 c.c. of subacetate of lead. The mixture is then heated and boiled for ten minutes. In order to promote clearness of the liquid 5 drops of a 10-per cent. solution of carbonate of soda are added; the mixture is then cooled down to the ordinary temperature, afterwards weighed again and the weight noted. Next the liquid is filtered and polarized in a 400-mm. tube. From the result so obtained the amount of sucrose is readily calculated.

In working with the beaker method, it is desirable to stir the megass from time to time in order to expel air-bubbles as effectually as possible, and in order to promote the extraction of the sucrose.

It is to be remembered that the water contained in the beaker after boiling and at the time of weighing consists not only of the unevaporated remainder of the added 300 c c., but also of the water contained in the megass. Geerligs gives a table for finding the amount of sucrose without calculation, but this is based on an assumed fibre content of 45 per cent. in the megass and approximately 55 per cent. water, and on the assumption that 20 grammes of megass are taken for analysis. Megass from single mills contains much less fibre than this, and it may be found necessary to calculate the sucrose when dealing with megass containing other amounts of water.

In this case it is desirable to take 26 grammes of megass for analysis, when the calculation becomes :—

$$\text{Per cent. sucrose in megass} = \frac{\text{Polarization} \times \text{weight of fluid}}{2 \times 100}$$

if a 400-mm. tube is used. If a 200-mm. tube is used, the division by 2 is omitted.

The weight of fluid is the weight of the residual added water plus the weight of water in the 26 grammes of megass taken.

(b) Soxhlet method. The sucrose may be determined by extracting a known weight of megass in a Soxhlet apparatus and polarizing the extract. A sufficiency of solution of basic acetate of lead should be added to the megass in the Soxhlet before the extraction begins; about 10 c.c. of solution are required for 26 grammes of megass.

WEST INDIAN AGRICULTURAL CONFERENCE, 1908.

(CONTINUED.)

FURTHER NOTES ON CANE FARMING AT TRINIDAD.

BY PROFESSOR P. CARMODY, F.I.C., F.C.S.,

Government Analyst and Professor of Chemistry, Trinidad.

During the last discussion which took place on this subject at the Agricultural Conference held in Trinidad in 1905 (*West Indian Bulletin*, Vol. VI, pp. 3-32), I promised to obtain some reliable figures as to the yield of canes per acre obtained by cane farmers in Trinidad. I am greatly indebted to Mr. J. McInroy, Manager of the Government estate (St. Augustine), for collecting the detailed yield obtained by 328 farmers on that estate, and thus enabling me to submit the following summary to this Conference :—

CANE FARMERS' CROPS (ST. AUGUSTINE).

		Tons.	Cwt.
Lowest yield per acre reaped	...		14
Highest „ „ „ „	...	29	12
Average „ „ „ „	..	11	14
„ „ „ „ rented	...	9	7

Number of cane farmers, with yield under	5 tons per acre	49
„ „ „ „ „ „	5-10 „ „ „	116
„ „ „ „ „ „	10-15 „ „ „	99
„ „ „ „ „ „ „	15-20 „ „ „	47
„ „ „ „ „ „ over	20 „ „ „	17
Total	...	328

The average yield of the seventeen farmers producing over 20 tons was 24½ tons per acre.

It was stated at the Conference of 1905 that the average yield obtained by 399 farmers holding 1,753 acres was 5 tons per acre; the above figures show that 328 farmers produced, on land of no better quality, an average of 9 tons 7 cwt. on the acreage held, and 11 tons 14 cwt. on the acreage cultivated. In 1905, I estimated the average yield to be 10 tons per acre, which is shown by the above return to be very nearly correct.

The figures are of great value to us in Trinidad, because we can now confidently represent to our cane farmers that an average yield of only 11¾ tons per acre cultivated, is far below what might reasonably be expected of them, and to our estate owners the manifest advantages of the share system of cane cultivation practised in Fiji, Hawaii, and Mauritius, and described by Sir Henry M. Jackson, K.C.M.G., in *West Indian Bulletin*, Vol. VI, pp. 18-21, and Vol. VII, pp. 311-6.

I am satisfied that it is on a co-operative system of production, such as this, that we must rely for the future stability of the sugar industry in Trinidad. Our central factories are well equipped for manufacture; and our principal weak point has been for many years in the cultivation. It is only quite recently that we have re-introduced mechanical implements for tillage; and these are almost confined to steam ploughs at present. The success of mechanical tillage in other countries, and the experience in this direction recently gained in the neighbouring colony of Antigua, should encourage us to adopt mechanical tillage to a much greater extent than has previously been attempted. And this can be done well under the share system of cultivation with its suitably balanced division of labour.

The heavy work of preparatory tillage should be done by mechanical implements, for which the cane farmer has not the capital to provide, in order, among other advantages, to ensure a sufficient feeding area for the roots. This is not available under the present method of hand tillage, and the result has been shown in the very small yield of 11 tons per acre. The lighter work of subsequent cultivation would be easily accomplished by hand labour provided by the farmers.

The estate owners would be better able to treat the cane tops before planting by immersion in Bordeaux mixture, or other similar preparation, which is now known to be neccessary for the prevention of fungoid diseases. The cane farmers cannot, or will not do this; and their plots will become centres of infection from which these diseases will spread.

The estate owners would provide the manures shown by experience to produce the best results on their land. The cane farmer can only provide pen manure, and very little of that. He has neither the money to purchase artificial manures nor the knowledge to apply them to the best advantage.

The money advances now made by estate owners, presumably for the above purposes, would be of more advantage if the expenditure were made in the ways above indicated, under proper direction and supervision.

An enormous advantage under the share system is the continuous control which the owner retains during the whole period of the crop. The return for St. Augustine estate shows that only seventeen out of 328 farmers could be exempted from control under any good system of cane cultivation; and the timely assistance which the manager of an estate could give in order to bring neglected cultivations up to a reasonable standard would be certain to increase the productive capacity of the land, and to serve as a valuable object-lesson in the advantages to be derived from intelligent and experienced supervision.

At one of the district Agricultural Shows, held last November, the estate owners voluntarily contributed four prizes, to which the Judges added a fifth prize, for the best farmers' canes then growing in the district. The result of this spontaneous evidence of the interest taken in good cane farming is reported to have been most beneficial, and as these prizes are likely to be offered in future years, there is every reason to expect a marked improvement in the small cultivations in that district.

In order to bring up to date previous records, I present the following table compiled from returns made to the Agricultural Society.

From this it will be seen that the number of cane farmers is still increasing and has more than doubled in the last ten years; and that notwithstanding this increase, the cane production on the estates has not diminished, except in the bad year 1905.

It can also be estimated (on the basis that the average yield per acre is 10 tons of canes) that from 17,000 to 20,000 acres of land are under cane cultivation by farmers. Under proper cultivation this acreage ought to yield at least 400,000 tons of cane, or double the presentout put:—

CANE AND SUGAR PRODUCTION, TRINIDAD.

YEAR.	Total Sugar Production.	Estate-grown Canes.	Farmers' Canes.	Price Paid.	Cane Farmers. Number and Nationality.	
	Tons.	Tons.	Tons.	$	West Indian.	East Indian.
1895	55,000	No return	35.000	...	..	...
1896	59,000	...	75,000	...	3,744	...
1897	55,000	...	...	..	. .	...
1898	58,000	. .	105,000	203,000	3,824	2,326
1899	58,800	426,000	106,000	219,000	3,870	2,826
1900	46,000	364,000	106,000	228,000	3,591	2,826
1901	61,000	434,000	170,000	369,000	4.737	3,819
1902	57,830	338,000	185,000	327,000	4,850	4,506
1903	47,000	337,000	166,000	348,000	4,440	4.443
1904	48,000	385,000	172,000	360,000	4,685	4,646
1905	38,240	244,418	144,868	482,053	5,462	5,424
1906	62,975	397,912	237,844	469,122	5,446	6.127
1907	50,564	395,863	166,993	340.527	5,777	6,557

DISCUSSION.

Mr. J. R. BOVELL (Barbados) asked whether the land referred to by Professor Carmody had not been out of cultivation for some time. As far as he could remember, the Government took over estate lands which had been out of cultivation for some time, and if this was part of the land referred to by Professor Carmody, that might account for the difference in yield.

Professor CARMODY said that was not the case. Although the land was out of cultivation so far as the manufacture of sugar by the proprietors was concerned, yet it had been let by the Government to tenants, and had been used for the purposes of cane farming ever since. It might be taken therefore, as fairly representative of the cane lands of Trinidad.

Hon. B. HOWELL JONES (British Guiana) said that very little cane farming was carried on in British Guiana, the difficulty being the means of transport between the various villages and the estates. The development of the rice industry therefore, does not in any way affect cane farming.

Dr. FRANCIS WATTS (Antigua) said that the basis of trading at Antigua was different to that described by Professor Carmody for Trinidad, although the effect might be somewhat similar. Peasants' canes were bought at the rate of 4½ ℔. sugar per 100 ℔. cane, which during last year realized 8s. 7½d. per ton of canes. He was unable to say how many acres there were in farmers' canes.

Hon. W. FAWCETT (Jamaica) said there was a small amount of cane farming going on in Jamaica at Westmoreland, where one or two small estates had abandoned their machinery and were selling their canes to large estates. But there were no peasant farmers as in Trinidad.

ROOT DISEASE OF SUGAR-CANE.

BY F. A. STOCKDALE, B.A. (Cantab.), F.L.S.,

Mycologist and Agricultural Lecturer on the Staff of the Imperial Department of Agriculture for the West Indies.

Of the fungoid diseases of sugar-cane in the West Indies, the root disease is considered at the present time to be the most important. This disease has probably caused more damage during the past few years than all other sugar-cane diseases together, and has been particularly prevalent in Barbados during the past two seasons, when the weather conditions have been somewhat unfavourable to a vigorous growth of the cane.

Root disease of sugar-cane in the West Indies is chiefly caused by *Marasmius Sacchari*, but it is thought that other fungi may be the cause of some of the damage noticed.

HISTORICAL.

A root disease of sugar-cane was described first from Java in 1895, when Wakker showed that much damage was done to the sugar-cane crops by the fungus *Marasmius Sacchari*. From 1899 to 1902, the root disease of sugar-cane in the West Indies was investigated by Howard, who concluded that the West Indian and Javan fungi were identical, i.e., that *Marasmius Sacchari* was the causative organism of the trouble. In 1904, Lewton-Brain forwarded specimens of the fungus of the root disease to Kew for identification, and the opinion of Howard was confirmed. In the third lecture of a series delivered by Lewton-Brain before the members of the Barbados

General Agricultural Society on the fungus diseases of sugar-cane, the root fungus was described at length; and the attention of planters was drawn to the economic importance of this disease. At the West Indian Agricultural Conference, held in Trinidad in 1905, a brief review of the disease was given by Lewton Brain, and later in the same year, a preliminary account was delivered by the same authority before the Sugar Planters' Association in Hawaii. Lewton-Brain and Cobb in investigating the fungus diseases of sugar-cane in Hawaii have found that a certain amount of root disease occurring in Hawaii is caused by a fungus that differs in but certain minor characteristics from *Marasmius Sacchari* as described by Wakker, and which they propose to call *Marasmius Sacchari*, var. *hawaiiensis*, and also that a considerable quantity of disease is due to a fungus—a new species described as *Ithyphallus coralloides*. It has however been mentioned by Lloyd, that evidences go to show that the fungus described by Dr. Cobb as *Ithyphallus coralloides* is most probably *Phallus aurantiacus*, a fungus that is fairly widely distributed throughout Hawaii and the tropics.

Recently, the diseases of the sugar-cane of Louisiana have been under investigation by Fulton, and specimens from thence have been submitted for examination to this Department, as well as to the agricultural departments of Java and Hawaii. The specimens clearly indicated that the canes were suffering from root disease, but the absence of fructifications rendered it impossible to identify the fungus. In August of last year, fructifications of the root disease fungus were obtained in Louisiana by Fulton, and were submitted to authorities for accurate identification. These proved to be not *Marasmius Sacchari*, but closely allied to it, being *Marasmius plicatus*.

In the monograph of species of the genus *Marasmius* found in America, recently published by Morgan, the fungus *Marasmius bambusinus* is also described from fallen culms of sugar-cane in Cuba and the Antilles.

During the past two years, collections have been made by the writer of the different organisms that are connected with the root disease of sugar-cane found in Barbados and other West India Islands. Several different fungi have been collected, of which *Marasmius Sacchari* would appear to be the chief, and have been submitted for accurate identification. It is impossible at the present time, to suggest even the relative importance of the several fungi collected, but suffice it to say that these fungi have been associated on canes that showed all the characteristic symptoms of root disease, and that their presence brings forward complications into the problem of searching for varieties of cane that are resistant to this disease.

The life-histories of the fungi are being closely followed, with the view of assisting planters further n combating this disease in their sugar-canes, and the relative immunity of the various seedling canes under cultivation is receiving careful consideration.

DISTRIBUTION.

It has been indicated by the foregoing remarks that root disease of sugar-cane is widely distributed throughout cane-growing countries. It is receiving considerable attention at the hands of mycologists, planters, etc. The problem of reducing the losses occasioned by this disease is of the greatest importance, especially to these West Indian Colonies. One has only to take but a glance over the cane fields of Barbados this year (where the weather conditions have been particularly unfavourable for the vigorous growth of cane) to realize how wide-spread it is. In the Leeward Islands also, reports of attacks have been received, and Dr. Watts says that 'observations lead me to think that root fungus is more widely distributed than planters imagine, and I would urge their very careful attention to this point.'

In Trinidad, in 1906, the attention of planters was drawn to a disease that was causing considerable damage amongst the canes of the Couva district. Frog-hoppers were supposed to have been responsible for the damage, but specimens forwarded for examination in the laboratories of the Imperial Department of Agriculture showed that 'the specimens of cane stumps forwarded for examination were attacked by root fungus, and several of the canes had been completely tunnelled out by some boring insect, so that it is quite likely that the unfavourable condition of the cane fields, from which the specimens were taken, may be largely due to other causes than the frog-hoppers, the supposed cause of the trouble.' This report has been confirmed by Mr. O. W. Barrett, who has recently been on special duty in Trinidad, in connexion with the diseases of plants of that colony, and who says that *Marasmius Sacchari* was responsible for 90 per cent. of the damage done to the canes.

SYMPTOMS OF THE DISEASE.

The symptoms of the disease are well-marked, and are known to most, if not all, of the sugar planters of the West India Islands. Affected shoots present a dwarfed appearance, and instead of, say, a dozen broad leaves, there are but six or seven narrow, pale-green leaves, the oldest of which show a tendency to dry up from the apex and margin and the youngest infold the two halves of the blade to prevent, as far as possible, undue loss of moisture by evaporation. These stunted canes never recover, but struggle on, giving a stool of dwarfed canes. If now we examine the bases of the canes in affected stools, the characteristic matting of the old dry leaf-bases to the stem by a felt of white mycelial strands is observed. If these matted leaf-bases are stripped off from the cane, further investigation shows that the sleeping roots at the nodes are diseased. Instead of being of healthy appearance, these roots present a reddish or brownish colour. Examination of the roots of the canes below ground shows that they have been affected and large numbers of them will be found to be dead.

How, then, does the root disease affect the growth of canes? It works damage in two ways: (1) It destroys the roots of

plants and ratoons; and (2) it injures and smothers the new shoots of ratoon stools:—

(1) The destruction of the roots is caused by the fungus entering and destroying the delicate cells that constitute the growing points. The fungus may first be detected in the most delicate cells under the root cap, but it has not yet been definitely established how the infection actually takes place. Once the root is affected, its growth is stopped. The water and salts in solution are taken from the soil in gradually reduced quantities.

The plants probably endeavour to replace the dying and dead roots by others: these in their turn are attacked and destroyed. For this development of new roots there is a constant drain upon the manufactured food materials of the plant, and at the same time the plant is getting more and more unable to supply the water and minerals necessary for the manufacture of food. We notice an effort to reduce loss of moisture by transpiration in the gradual reduction of the surface area of the leaves and the inrolling of their margins. By this means an attempt is made to balance between loss of moisture and reduced absorption. There, therefore, result small and light canes as the outcome of this gradual starvation.

(2) The destruction of new shoots in ratoons is often of a serious nature, for the matting of the white fungal mycelium would indicate that many young shoots are either smothered or injured, especially in ratoons. As Dr. Cobb says: 'When one sees the efforts of the plant to produce new shoots time after time defeated by its enemy, observes the weak and tardy character of the shoots that do succeed in getting above-ground, and observes and counts the number of absolute failures in ratooning, he will realize what losses his fields are sustaining through the attacks of root disease.' The exact manner in which this destruction of the young shoots takes place has yet to be more fully investigated, for it has yet to be ascertained whether the fungus itself is capable of attacking the young shoots as well as the young roots. It sometimes happens that young shoots die off and are found to be penetrated in all directions by a fungus similar in appearance to that in the young roots, and therefore it may be supposed that direct infection has taken place. Probably the most serious damage to the young shoots is caused by the fungal mycelium forming a closely woven felt over them, and thereby gradually smothering them.

SPREAD OF DISEASE.

The disease spreads by three methods: (1) By the spores borne by the toad-stool-like fructifications, (2) by the mycelium that travels underground, and (3) by the planting of affected cane cuttings.

The fructifications are not produced all the year round and therefore spores account for but a small percentage of the destruction incurred. The mycelium is able to live on dead organic matter in the shape of old trash, etc., in the soil, and therefore spreads throughout a field fairly rapidly. Affected cuttings are also a means of spreading the disease.

REMEDIAL MEASURES.

We now have to consider the remedial measures that are likely to be of benefit in the treatment of the disease. It is necessary that we should have a clear understanding into the life-history of the fungus, for then we are the better able fully to understand those measures that are likely to prove of benefit.

The majority of the species of the genus *Marasmius* are saprophytic in habit. The fungus *Marasmius Sacchari*, however, has been shown to be a facultative parasite, i. e., a fungus that may be saprophytic at one stage of its life-history and parasitic at another. It is only *weakly* parasitic. In root disease the host and fungus are very evenly matched and, therefore, it is really an up and down fight between the two when they are together. Any circumstances that are likely to disturb external conditions may tend to send the balance in the favour of either the fungus or the cane. Every effort therefore should be made to increase the vigour of the canes by careful attention to cultural methods, etc., for thereby they may better withstand the attacks of the fungus.

The remedial or preventive measures may be divided into (1) cultural improvements, (2) sanitary measures, (3) selection of disease resistant varieties.

(*1*) *Cultural Improvements.*

(*a*) A cane growing vigorously is not likely to be affected seriously, and therefore under favourable conditions the sugar-cane is capable, to a great extent, of successfully warding off attacks of root fungus. It would appear to be difficult for the fungus to attack healthy, vigorous, living tissues, but the tissues are easily overcome when that vigour is in any way impaired. As the vigour of the cane decreases, the damage occasioned by the attack of fungus increases. Thorough and careful cultivation should always be practised therefore, for this allows of good development of the roots and at the same time weakens the fungus by aeration of the soil.

(*b*) Ratoons are always much more badly affected by the root fungus than plants, and it is naturally suggested that the ratoon crops should therefore receive careful attention from the cultivators' point of view, in order to promote root development during the early rains. In Barbados, however, it has been found that forking of the ratoons disturbs the capillarity of the soil and possibly the stumps themselves to an extent that does more harm than the resulting aeration, etc., of the soil does good. In dry districts especially, the cultivation of ratoons has been found to do harm, though some good may accrue from careful tillage of ratoons in wetter districts. Experience on this point in the other islands has yet to be gained, for the conditions vary sufficiently to make it impossible to base general suggestions for remedial measures on the results of Barbados experiments alone. On fields badly affected with root disease, it may even be better to

abandon ratooning until they may reasonably be reduced to the minimum of fungus content. A badly affected ratoon crop gives the fungus an opportunity for getting a good hold, and not only will that crop barely pay expenses, but the field may bear many short crops for several years afterwards.

(*c*) The drainage of all fields should be properly attended to, and when the fungus makes its appearance in isolated spots in fields it may satisfactorily be confined to that area by the digging of isolation trenches of 18-24 inches deep. Root disease has frequently been observed to be prevalent upon heavy clay soils where subsoil drainage is not well looked after.

(*d*) Where root disease has shown itself to be at all prevalent, careful attention should be given to the rotation of crops. In this way the fungus may be starved out. In such portions of these colonies where cane is the only crop grown, the fields affected should be rested from cane and thoroughly tilled for a year or two, while in those islands where cotton can be successfully grown, a remunerative crop for rotation with sugar-cane offers itself and gives planters a chance of resting badly infested fields for a year or two from sugar-cane, and at the same time keeps the land in crops that pay well. Other crops such as sweet potatos, yams, and Indian corn offer themselves as rotation crops, although it should incidentally be mentioned that the first-named crop has been found to be attacked by the mycelium of a fungus that resembles very closely that of the root disease of the sugar-cane. It cannot be expected that rotation for one season will satisfactorily get rid of the whole of the root fungus accumulated in badly diseased fields. In Surinam, and I think also in British Guiana, success has been attained when sugar-cane fields have been thrown out, flooded, and allowed to remain out of cane for two seasons. Constant rotation of crops will assist, however, in considerably diminishing the amount of fungus present.

(2) *Sanitary measures.*

(*a*) The value of lime as a fungicide is gradually becoming more fully recognized, and it has been asked whether the good results that accrue from applications of lime in many sugar-producing countries are really due to indirect manurial effects and clay-flocculating actions (as is generally supposed), or whether they are not rather due to the action of the lime on the living enemies of the cane. It is very probable that in many instances improvements of crops have resulted from the destruction by lime of some of these parasitic organisms. The use of lime on sugar beds in Hawaii has recently been on the increase, and it has also been found that lime and cowpeas have shown to be suitable treatment from a manurial point of view for many of the cane soils of Jamaica. Dr. Cobb, from Hawaii, in drawing attention to the use of lime as a disinfectant in cane fields, says that 'from a disinfecting point of view I should recommend the following method: Apply the lime as nearly unslaked as possible and in the maximum quantity the bed will stand (up to at least 1½ tons per acre),

and apply it along the old stubble (stumps) before ploughing and let it remain a few days to sink in.'

A large amount of fungus is found attached to the base of the leaf stalks of thecanes, binding them closely to the stem. When the canes are cut, there is still a considerable quantity of fungus accumulated in the centres of the old stumps, and it is probable that much of this may be destroyed by applications of unslaked lime. Each stump should receive, if possible, attention, and the lime should be applied as soon as possible after the canes are cut, before the ratoon shoots have sprung. It is also to be advised that trials should be made with this method of application, and also by making applications in grooves cut by disc ploughs on either side of the rows of cane stumps. The present situation of the root disease in the West India Islands, I think, justifies the commencement of experiments, under varying conditions, in connexion with the application of lime as a fungicide for this disease. Various methods of application should be tried, and it should be remembered that every effort should be made to give each root-diseased stool its proportional dose. The experiments should be looked at from a mycological point of view, and if it is found that the disease-producing power of a field can be reduced by the application of even large doses of lime, an important advance will have been made in the treatment of the root disease of the sugar-cane. At present, it is too early even to express any opinion as to the possible results, for there are many points that must receive consideration. The reduction of the organic matter in the soil by the lime and the possible reduction of the amount of moisture, the upsetting of the nitrification changes by the application of large doses of lime are matters that must receive attention, but it may reasonably be expected that properly conducted experiments along the right lines might answer the question as to the real disinfectant value of lime in the root disease of sugar-cane.

(*b*) Destruction of infected material.—All cane stumps infested with *Marasmius* mycelium should be removed from the field and destroyed, or at the least should receive applications of lime and then split into as many pieces as possible and turned out into the full rays of the sun. Trash from infested fields should not be used in cane fields and should not be made into pen manure for application to canes. The disposal of diseased trash economically and sanitarily is a question that demands attention at the hands of planters, etc., especially as trash and pen manures plays such an important part in the successful growing of canes in these colonies. From a phytopathological point of view, all badly diseased stumps or trash should be rigorously destroyed, but it would seem possible that but slightly affected material might be made into pen manure for application to cotton, etc., when careful rotation of crops is practised, without endangering to any considerable extent the crops of canes that are to follow. The question of the disposal of the megass of diseased canes from up-to-date factories has recently been under investigation, but until it can definitely be established that living mycelium is *not* present in such megass, it should be considered

as diseased material and treated in a manner similar to that advised for infected trash. [It has been asked whether megass from diseased canes applied as a mulch to a field of cane may account for an undue development of root disease in that field, but until careful investigations have been made, a satisfactory answer cannot be given.]

(c) Diseased trash should be kept from all cuttings and plants, for by this means the canes will make vigorous growth and will not become as early infected as if the diseased trash were in close contact with the growing canes.

(d) The greatest care should be taken in selecting cuttings for planting purposes. Canes badly infested with root disease are frequently used for planting purposes, and serve as a centre from which the fungus may spread to the surrounding plants. A careful inspection of canes for planting purposes with the rejection of all suspected ones should be practised; and it would also be advisable thoroughly to disinfect all cane plants in Bordeaux mixture in order to destroy the fungus that may be attached to the slightly affected canes that may be overlooked in the inspection. The results of the different disinfection experiments conducted in the West Indies have already been placed on record, and Dr. Watts adds in his report for 1903-4, that Bordeaux mixture is now being fairly extensively used for the treatment of cane plants in Antigua, and there seems good reason to believe that it is proving of service in those cases where canes are being planted in spots liable to the attack of root disease. Recently elaborate series of experiments have been carried out in Hawaii by the Division of Pathology and Physiology of the Hawaiian Sugar Planters' Association with reference to rendering the cuttings immune from attacks of fungi.

(3) *Disease-resistant varieties.*

Up to 1904, it was thought that root disease attacked equally well all varieties of cane at present in cultivation, but it has been found that many of the seedling varieties appeared to be more or less immune to its attacks, or were capable of warding off attacks for a much longer period than the older varieties. It was thought in 1904, that we still had to find a cane resistant to root disease, but since then a good deal of information has been collected in respect to the seedlings under experimental cultivation at Barbados. This has now been carefully tabulated, and although we cannot say that we have, at present, any cane that is thoroughly capable of withstanding entirely the attacks of *Marasmius Sacchari*, yet there are several that generally have shown that they are but slightly affected, even when we have a bad year for root disease, while others are very badly affected. As described in the *West Indian Bulletin*, Vol. VIII, p. 86, in a paper prepared for the last Agricultural Conference held at Jamaica in 1907, on Breeding Hybrid Sugar-canes, a series of experiments has been commenced to inquire into the disease-resistant power of various varieties used in hybridization experiments. Four canes, viz., B. 6,048, B. 1,529, B. 3,289, and B. 208, chosen as

being either immune or suffering little from the attacks of the fungus that causes this disease, are to be crossed with two others—B. 3,668 and B. 3,696—that appear to suffer fairly severely from this parasite.

It is with satisfaction that I can now report that there are ten hybrids in this series at present growing, as the result of work carried out in November and December 1907, and I am not without hope that more will yet make an appearance, for the arrows have only been recently sown.* These hybrids will be watched with interest, particularly with respect to their disease-resistant characters, for if definite information can be obtained in respect to this pair of characters (disease or not), a great advance will have been made in the breeding of hybrid sugar-canes under strict scientific control. These experiments are yet in their infancy, and many years' work must yet be done before tangible results may be expected.

SUMMARY.

In many of the sugar-cane growing countries of the world a root disease similar to the one found in the West Indies is known and is fairly widely distributed. Remedial or preventive measures on the lines briefly outlined in this paper have been given a fairly satisfactory trial. In the West Indies, several planters have attacked the question of the root disease and adopted remedial measures with encouraging results. Further experiments are in hand, particularly with the use of lime as a fungicide, and with the disinfection of cane cuttings. In Hawaii the work of eradication has recently been commenced by the Division of Pathology and Physiology of the Sugar Planters' Association, and the problem has also been attacked by Fulton in Louisiana. In Java, where the root disease was first worked at, it is reported that Prinsen Geerligs stated that it is now difficult to find specimens of the root fungus in Java. The system of rotation, with the elimination of ratoon crops, and the great care taken with material for planting purposes have played an important part in bringing about this result. Is it now therefore, necessary, that the West Indies should make every effort to completely rid themselves of a disease (or considerably to reduce its amount) that is prevalent in many of the cane fields.

DISCUSSION.

The PRESIDENT: Mr. Stockdale's paper when it is published, I think will be read with great interest. He has presented his facts in such a manner, that I believe there is a possibility of the root disease of sugar-cane receiving very considerable attention, by the various planters. It is fortunate that we have cotton as a rotation crop in canes, because one of the

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*Twelve hybrids obtained by artificial fertilization and thirteen obtained by natural methods were planted out in May 1908, together with 244 self-fertilized seedlings of known parentage. Of these, eleven hybrids and 122 self-fertilized seedlings belong to the 'disease series.' In addition to the above, 400 other seedlings of possibly unknown parentage are under observation in these experiments.

most effective means of getting rid of any root disease is to change the cultivation, so that the fungus in the soil may be, in some measure at least, starved out.

Mr. BOVELL (Barbados) stated that about a month ago he took twelve sugar-cane cuttings, and soaked six in Bordeaux mixture and the other six in water only. These were planted out, and while those that were soaked in water only were affected by the fungus disease of cuttings, those soaked in Bordeaux mixture were unaffected. A fair amount of root disease was, at present, to be found in Barbados, and frequently planters us ed badly affected cuttings for planting purposes. Mr. Bovell then exhibited a stool of canes badly affected with root disease, and also showed the specimens of cane-cuttings soaked in water and in Bordeaux mixture above referred to.

Dr. WATTS (Antigua) said that there was a fair amount of root disease of sugar-cane in the Leeward Islands. He was perfectly convinced, however, that they did not fully recognize the importance of taking every precaution against this disease. A planter frequently noticed the white felted mycelium upon the trash, but thought that it was not doing any damage to his canes. This might be perfectly true. The fungus was then saprophytic in habit, and was present to do damage whenever the opportunity was given for its favourable development. This attack on the trash, however, was of greatest importance, for it was the means by which the fungus was spread in the ground.

If stress was laid on the fact, that although the attack on the trash might not be very serious, yet it was a great source of danger when worked into the soil to the roots of the subsequent crop and as a means of spreading the disease, then planters would realize the position and adopt the necessary remedial measures. He would ask Mr. Stockdale for a definition of what he called 'infected plants' and where the danger lay in infected plants. He should also like him to explain whether by 'infected cuttings' he meant anything that showed signs of the disease on the trash; or whether the infection was in the body and tissues of the cane itself? Further, if the infection lay on the outside of the cane in the infected trash, would Bordeaux mixture prove a means of arresting the disease? He desired that this matter of 'infected cuttings' and treatment with Bordeaux mixture should be made perfectly clear.

With regard to infected megass, where the disease was very bad, he thought it was best to burn the megass. It would be interesting to have experiments carried out, which would show how the fungus could be handled in infected material. There was a natural tendency to return the megass from the factories to the land as manure, and in some cases it was put into pens to be subsequently used as manure. This megass was sometimes infected with root fungus. Now, should they tell the planter that he must not use megass as manure and had better burn it; or should they tell him that he could run the risk and keep his canes in a vigorous condition so that they could resist the disease? That was a point of importance. He could say with some gratification, that Bordeaux mixture was

now used throughout the Leeward Islands as a routine method of treating plants before they were put into the land. On this subject of root disease, he would strongly urge upon planters in the West Indies, that they should pay every possible attention to the matter, and appeal to the scientific officers amongst them for further advice to enable them to combat a serious disease. He would also like to ask Mr. Stockdale whether the fungus attacked such plants as Guinea corn or imphee.

The PRESIDENT drew attention to the pamphlet on fungus diseases of the sugar-cane that was prepared by Mr. Lewton-Brain in 1904, and stated that it was desired to draw the attention of all planters throughout the West Indies to the present position of fungus diseases of the sugar-cane. The Imperial Department of Agriculture had continually drawn attention to diseases of the sugar-cane, but he thought that it should be emphasized that the root disease of sugar-cane was, at present, doing damage—particularly amongst some varieties.

In the pamphlet above referred to, it was mentioned that, making every allowance for unfavourable seasons and other circumstances, the loss caused by the attacks of fungus diseases in Barbados during 1903 was 10,000 hhds. of sugar of the value of £70,000 ; and taking into account the loss sustained in molasses also, the total loss in the year 1903 did not fall far short of £100,000. He believed the White Transparent was possibly the most affected of any cane in Barbados, and there was a great danger that this cane, which had hitherto proved so valuable might be seriously attacked by the disease and might at some date have to be replaced by some of the newer varieties.

The root disease of sugar-cane had received considerable attention by the scientific officers of the Department, and in bringing up this matter at the Conference, it was desired to emphasize that the time was fast approaching when it would be necessary for planters all over the West Indies, where this disease was at all serious, to take the most stringent steps possible for combating it. Remedial measures had been indicated by Mr. Stockdale, but it was necessary that further experiments should be carried out by the planters in co-operation with the Department in order that further information might be obtained.

Hon. F. J. CLARKE (Barbados) inquired whether when canes were dead and trash was found adhering to them along with the mycelium described by Mr. Stockdale, the disease mentioned was the cause of the death of the plant in all cases, or whether the roots had been searched to see if there was a borer cutting them. In going through fields of ratoon and plant canes he had seen places where some of the canes were dead, and where others were dying. In almost every stool handfuls of grubs were found cutting the roots—in some cases the roots had been cut underground in all directions.

Mr. BOVELL stated that he had recentlv gone in a field of first crop canes, and on attempting to pull out a cane

the whole stool came up. The stool was affected by root disease, but he did not see any grub. Careful search for grubs was perhaps not always made, but the matter would be carefully investigated.

Mr. A. P. COWLEY (Antigua) said he was connected with several estates in Antigua where the soils ranged from light to heavy. Root disease seemed to be fairly well distributed, but had always been more prevalent in the heavy soils. It usually commenced in heavy soils, and gradually worked up until it reached the light soils. Whether the manure had anything to do with it he did not know, but estates which had the largest quantity of pen manure suffered much more from the disease than those on which other manures were used. That was the experience of all the Antigua planters. Bordeaux mixture was now generally used for soaking cane cuttings, and the labourers in planting canes had remarked its beneficial effect, for less supplying had to be done. The results obtained were highly satisfactory.

Hon. E. G. BENNETT (St. Lucia) stated that in St. Lucia they were practically exempt from root disease. It occurred here and there, but was not very prevalent.

Mr. STOCKDALE stated, in reply to Dr. Watts, that root fungus damaged plants in two ways. It attacked the roots themselves, destroying the young roots as they were thrown out from the cutting, and it smothered the young shoots of ratoon stools. By infected cuttings were meant cuttings that were taken from diseased canes. Canes that had trash matted by the fungus around the basal portion of the stem should never be used except as 'top' plants, for the sleeping roots at the nodes, after the infected trash is taken off, will be seen to be diseased. They present a brownish-black appearance and will not grow. Any cutting from such a portion of diseased cane must commence with a greatly reduced number of roots, and will also have sufficient fungus present to destroy a large quantity of those that will be put out. As to the effect of Bordeaux mixture on the disease, he had no evidence that it would check the disease entirely, but he believed that a considerable portion of the fungus would be destroyed if cuttings were steeped in Bordeaux mixture for some time before being planted. With reference to Guinea corn and imphee, be mentioned that he had not seen either of these plants infected by the root fungus.

The PRESIDENT remarked that that matter of Guinea corn and imphee being attacked by root fungus was investigated by Mr. Lewton-Brain, but he did not find that they were affected, and it was not considered that root disease might be carried on imphee or sorghum to the sugar-cane.

Mr. STOCKDALE, replying to Hon. F. J. Clarke, said he had found canes which had been killed entirely by the root fungus. He had not noticed any grubs particularly, but he would in future give the matter careful attention.

The PRESIDENT said that in cases like those mentioned by Mr. Clarke, the Department wanted information from the planter who was on the spot and could see everything. It

was desirable that these experiments should be the result of the combined efforts of the planters and scientific officers. Dr. Watts had very properly said that he wanted the experiments in the West Indies, to be co-operative experiments.. He hoped planters would take that view of the matter and would assist the Department as much as they could in the direction suggested.

Hon. F. J. CLARKE inquired whether in case root disease attacked the canes, deeper draining would produce beneficial results.

Mr. STOCKDALE replied that root fungus was often prevalent on badly drained heavy clay lands, and that in his paper he had stated that particular attention should be given to drainage, as a means of assisting in combating the disease.

Hon. F. J. CLARKE said he would like to know whether they could apply infected pen manure to rotation crops, and whether they were to understand that the rotation of crops would mean the planting of cotton or corn or sweet potatos or imphee before the canes were planted, and whether there was any likelihood of the disease remaining in the land and affecting the succeeding sugar crop. This point, raised by Mr. Stockdale, was a very important one, because planters in this island were accustomed to think that it was utterly impossible to grow canes without pen manure, and he would like some clear and definite understanding in the matter.

Mr. STOCKDALE replied, that when he raised the question of the application of trash or pen manure from slightly infected material to rotation, he brought it forward tentatively. It was a point which deserved careful consideration at the hands of planters and should be given a trial. From a scientific point of view no infected material should be applied to the sugar crop; but he knew that in practice, it was difficult to carry this point to an extreme, for it was generally recognized, in Barbados at any rate, that the supply of humus must be kept up, and that therefore one had to consider the matter from various points of view before it could be definitely recommended what trash should be burned.

The PRESIDENT: The point raised by Mr. Clarke is this. Suppose that the canes having been reaped, the land is planted up with cotton, imphee, sweet potatos, and so on, and pen manure is applied, is there any likelihood of the *Marasmius* remaining in the land and affecting the succeeding sugar crop?

Mr. STOCKDALE said that in badly infected fields it had generally been experienced, that rotation of crops for two or three years would eliminate danger in that respect. While the amount of fungus in the soil would be greatly reduced by a single rotation, he was not prepared to say that the planter could get entirely rid of the disease in one season.

Professor J. B. HARRISON said they did not have much root fungus in British Guiana. They had it in patches, and sometimes it had done a great deal of harm. About twelve years ago, when it was very bad in some parts of Windsor

Forest plantation, Mr. R. G. Duncan suggested that they should open the drains and put the fields under water for four or five months. This successfully destroyed the disease. Then they had a system of burning the fields before they planted canes, by setting the trash on fire, thus scorching the fungus and other things as well. There was no doubt that the system of dividing into sections lands in which canes were growing, tended to prevent the spread of root disease to a great extent.

The PRESIDENT, in bringing the discussion to a close, said that this was an important matter which they might have brought up at the various Agricultural Societies, when practical questions such as had been raised could be threshed out much more fully and satisfactorily than at this Conference. As regards British Guiana, the soil was cut up so extensively by cross drainage that the fungus had no opportunity to travel over wide areas. It would be observed that the disease sometimes attacked one corner of a field very badly. In such a case, a deep drain should be dug across—not close up to the diseased plants, but some distance beyond them—so as to cut off that area from the other parts of the field and prevent the disease from travelling through the soil. This system had been adopted in some instances and the result had been very favourable.

THE POLARIMETRIC DETERMINATION OF SUCROSE.

PARTS IV, V, VI, AND VII.

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Parts I, II, and III of this series of papers have already appeared in previous numbers of the *West Indian Bulletin.* Parts IV, V, and VI were of a more technical character, and were read before the Society of Chemical Industry. It is now proposed to give brief abstracts of these last three papers in order to admit of the publication of Part VII, in which a complete summary and review of the work is given.

PART IV.

The Effect of Basic Lead Acetate on the Optical Activity of Sugar Solutions.*

The question of the validity of the polarimetric reading of a solution of a normal weight of a sugar in a standard bulk of water as a measure of its actual sucrose content is at the present time the subject of much discussion. The process is admittedly liable to errors, and consequently every effort should be made to secure analytical uniformity in its performance.

In previous papers we have discussed some of the various sources of error, namely : The influence of temperature on the specific rotation of sucrose, the method of performing the Clerget inversion process, and the influence of the volume of the precipitate formed by clarification with basic lead acetate, which by its displacement volume occasions a concentration of the sugar solution on making up to bulk, when a solution of the reagent is used as clarifying agent.

In consequence, the adoption of the anhydrous basic lead acetate defecation process of Horne was advocated as tending to eliminate this error.

The results have been criticized, on the ground that the lead precipitate absorbs sufficient sugar from the solution to neutralize the effect of the precipitate volume, by H. and L. Pellet, and these criticisms have been met by Horne.

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* Read before the Society of Chemical Industry, December 2, 1907, and published in the Journal of that Society, Vol. XXVII, No. 2.

Apart from these considerations, the process of lead clarification is usually believed to possess fundamental inaccuracies by reason of the action of the lead salt on the impurities occurring in commercial sugars, etc., notably invert sugar.

This effect was first pointed out by Gill in 1871, and his results were repeated and confirmed by Bittmann in 1880.

Ideas on this subject at present are very vague, and it is believed by some that the action of basic lead acetate is to produce an insoluble levulosate of lead.

An investigation was made of the effect of increasingly large amounts of basic lead acetate solution on the optical activity of solutions of invert sugar. The effect observed was small at first, ·5 c.c. of lead solution in 50 c.c. of invert sugar solution, which polarized - 10·40°V. when without addition, occasioned a lowering of only ·06°V.: larger amounts increased the lowering, till with 15 c.c. of lead solution, the limit of the experiment, it had fallen 8·81°V., from - 10·10 to - 1·59°.

It was shown that this effect could be overcome by the addition of acetic acid, the amount of acetic acid required being found to be equal to that required to effect combination with the basic portion of the amount of lead salt present in solution. Hence it was concluded that the effect was entirely due to the formation of levulosates by combination with the basic portion of the salt, and that, consequently, the neutral salt would not occasion such changes. This conclusion was found to be correct, by experiment, in which the addition of 5 c.c. of neutral lead acetate solution was shown to be without effect on the optical rotation of invert sugar.

By reason of the smallness of the lowering experienced with small excesses of basic lead acetate, the authors conclude that if care is taken to avoid excess of lead salt, the error likely to be introduced into the determination by the use of this reagent, in consequence of its interaction with invert sugar, is negligible in the case of the average run of raw cane sugars and cane juices.

The validity of these conclusions was tested by observations on solutions constructed to represent actual cane juices and sugar solutions. Pairs of similar solutions were prepared containing equal amounts of cane sugar and invert sugar, but to one was added a solution of organic matter precipitable by basic lead acetate, prepared by decomposing with sulphuretted hydrogen the lead precipitates obtained from juices. This solution of organic non-sugar contained no optically active substance. The two solutions were made up to 100 c.c.; the solution containing organic non-sugar was defecated with anhydrous basic lead acetate and filtered; both solutions were then polarized. As a result, it was found that when moderate amounts of invert sugar were present, the polarization was absolutely unaffected by clarification with basic lead acetate.

In the concluding portion of the paper we discuss the methods at present in vogue for the clarification of molasses

and suggest, as an improvement on older methods, the use of a double normal weight of molasses, partial clarification with anhydrous basic lead acetate, filtration and completion of the clarification of 50 c.c. of the filtrate with sulphur dioxide: this solution is then made up to 100 c.c., filtered and polarized. This method is claimed as a considerably nearer approach to accuracy than those at present in vogue.

Mention is also made of the results recently obtained by Bates and Blake concerning the effect of basic lead acetate on the optical rotation of sucrose.

Finally we conclude that, when excess is avoided, clarification of sugar solutions with anhydrous basic lead acetate involves no appreciable error.

PART V.

The Effect of Clarification with Basic Lead Acetate on Cane Juice.*

In this paper we review the various methods of clarifying cane juice with basic lead acetate and point out what are the advantages of the dry lead acetate method, since by its use the error of the lead precipitate volume and also the accurate measurement of juices and solutions are avoided, whereby an increase of accuracy and a saving in time are effected.

In order to throw light on the mechanism of the reaction, the amount of lead oxide contained in the precipitates from the juices of five cane varieties was determined and found to vary very little, averaging 53·08 per cent.

It was observed by us that cane juice clarified with basic lead acetate always contained lead. Yet, on the other hand, further addition of basic lead acetate occasioned the precipitation of a yellow body. This effect was not obtained with neutral lead acetate.

Analysis of this precipitate showed it to contain 81·63 per cent. of lead oxide.

A quantity of this precipitate was suspended in water and decomposed with sulphuretted hydrogen; the resulting solution of organic matter was concentrated to small bulk on the water bath.

Examination of the resulting solution showed that it gave a precipitate with basic lead acetate, but not with moderate amounts of neutral acetate, alkali, acid, and alcohol.

We concluded that this substance is probably pectinous in character. The presence of lead in the clarified juice is, in

* Read before the Society of Chemical Industry, December 2, 1907, and published in the Journal of that Society, Vol. XXVII, No. 2.

our opinion, due to neutralization of a part of the basic lead acetate by the natural acidity of the cane juice, whereby it is converted into a neutral salt which remains in solution. Juices which have been clarified with lime do not show this phenomenon to such a marked extent.

The presence of lead in lead clarified juice suggested the enquiry as to whether any effect was exerted by it on the subsequent analytical operations. It appeared that the lead, if present as the neutral salt, would not affect the optical activity of levulose.

It is at present very largely the current practice among sugar house chemists to perform the determination of the reducing sugars present in cane juice on the lead clarified juice, though some, including ourselves, use raw juice for this purpose. It remained to be seen, therefore, if any difference existed between the results obtained by the two methods and, if so, whether this was due to the presence of lead in the juice, since it is known that the presence of lead is liable to affect the determination.

A series of determinations of the reducing sugar contents of the juice from eleven varieties of cane was made both on raw and on lead clarified juice, with the result that it was found that, on the average, the raw juice contained ·015 per cent. more reducing sugar than the clarified juice.

This difference is so small as to be immaterial in juice analysis, at the same time it became worthy of inquiry whether the effect was occasioned by the presence of the lead in the solution.

Accordingly, increasingly large amounts of a solution of basic lead acetate of the usual strength were added to a solution of invert sugar of known strength, and the apparent reducing sugar content of the mixture was determined by titration against Fehling's solution.

As a result it was found that, on the average, the presence of 1 c.c., of basic lead acetate solution was equivalent to the apparent removal of 0·006 gramme of reducing sugar per 100 c.c., and it would require an excess of at least 2 c.c. of basic lead acetate solution to produce an effect equal to that observed. It may be mentioned that the excesses that could occur in practice would be far below this.

Hence it follows that the excess of lead is not responsible for the observed small difference, which is probably owing to the removal of some small amount of reducing substance from solution during clarification. We cannot say what this substance is; it could not well be dextrose or levulose, but it does not appear improbable that the organic non-sugar removed from the juice by lead defecation may contain bodies capable of producing the observed small effect.

PART VI.

Some Observations on the Keeping Power of Fehling's Solution, together with Notes on the Volumetric Process of Determining Reducing Sugars with it.*

For this paper, it is pointed out that, contrary to the commonly expressed idea, Fehling's solution, or at least Violette's modification of it, is not liable to deteriorate rapidly if kept in the dark, and if access of air is prevented. The solution can thus be kept mixed ready for use and it is not necessary to keep the stock in the form of two solutions to be mixed as required.

General observations made over a series of years in the Government laboratory for the Leeward Islands, support this view. It is also confirmed by specific experiments. In the first series of experiments the solutions were kept in bottles exposed to diffused daylight on the laboratory shelves; in the second, the bottles were covered with brown paper and kept in a dark cupboard. The results obtained were as follows:—

Original Invert Sugar Equivalent of 10 c.c. of the solution = 0·0437 gramme.

A. After fourteen months keeping in daylight.

1.	Bottle full, 10 c.c.	= ·0397	gramme invert
2.	„ half full, „	= ·0387	„ „
3.	„ „ surface covered with kerosene oil 10 c.c.	= ·0412	„ „

B. After fourteen months keeping in the dark.

1.	Bottle full, 10 c.c.	= ·0442	gramme invert
2.	„ half full, „	= ·0428	„ „
3.	„ „ surface covered with kerosene oil 10 c.c.	= ·0442	„ „

The above results clearly show that in fourteen months the solution kept in the dark has in all cases undergone little or no change, while the same solution kept exposed to the action of light for the same length of time has undergone an appreciable amount of decomposition. Keeping the surface of the liquid protected from the free access of air also appears to have an appreciable effect in retarding decomposition.

An examination of the laboratory stock of this solution showed that, out of a large quantity (some 14 litres) prepared in February 1905, a quantity of some 3½ litres remained unused in March 1906. As originally prepared, 10 c.c. of the solution were equivalent to ·0453 gramme of invert sugar. At the expiration of about thirteen months, the remainder of the solution was found to be of such a strength that 10 c.c. were equivalent to ·0446 gramme of invert sugar—a difference ·0007, or a change of 1·5 per cent.

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* Read before the Society of Chemical Industry, January 6, 1908 and published in the Journal of that Society, Vol. XXVII, No. 5.

The method of determining the end-point of the reaction, when Fehling's solution is used, in volumetric determination is next discussed. After reviewing the methods usually in vogue, including Pavy's modification, and the filter-tube of Wiley and Knorr, we describe the method now employed by us.

This consists in filtering drops of the solution on small specially arranged pads of filtering paper. A sheet of specially toughened filter paper forms the top layer. This is placed upon two sheets of filter paper of a rough, fairly open type. These layers of filter paper are then cut into squares of about 1 sq. cm.

The liquid to be tested is dropped on the hardened filter paper and allowed to soak through the three layers; the two upper layers of filter paper, containing all the precipitated cuprous oxide are rejected, and the spot of liquid on the lower one is tested for unreduced copper with ferrocyanide and acetic acid.

The actual process of performing the determination is as follows:—

Ten cubic centimetres of Fehling's solution are measured out into a small beaker of about 100 to 150 c.c. capacity, and to it is added an equal quantity of distilled water.

The solution is brought up to boiling point on a sand bath and the reducing sugar solution added from a burette. The reducing sugar solution is added until the blue colour of the liquid is no longer distinctly visible, and then, after each fresh addition of reducing sugar solution, a drop of the liquid in the beaker is transferred to one of the special filtering pads and tested with ferrocyanide solution as above; the end-point of the reaction is shown when no brown colouration is occasioned by the action of the ferrocyanide solution.

The Fehling's solution is standardized against a standard solution of reducing sugar (invert sugar) in an exactly similar manner to that stated above, so that any intrinsic error in the process is thereby allowed for, in performing the determination.

Several advantages are claimed for this method. Amongst them are accuracy and rapidity of working and consequent freedom from error due to the action of the hot alkali on any sucrose which may be present.

The effect which the presence of sucrose exercises upon the determination of reducing sugars is discussed and studied. As the result of a number of determinations, we found that when sucrose is present, each gramme dissolved in 100 c.c. of the solution under examination possessed reducing power equal to ·0033 gramme of invert sugar dissolved in the same volume, and we advocate the use of this factor by way of correction of the amount of invert sugar determined in the presence of known quantities of sucrose.

It is shown that, in the absence of this correction, the amount of invert sugar determined by Fehling's solution in such cases as that of raw sugars, may be seriously in error.

The question is discussed whether it is desirable to use, for the determination of invert sugar, solutions which have, or have not, been clarified by means of basic acetate of lead. The question is left an open one, but it is stated that our practice is to carry out the volumetric determination on the untreated solutions as is usually the case in British, as contrasted with Continental practice.

Considerable accuracy is claimed for the volumetric process under the conditions laid down, but for rigidly accurate work the gravimetric method is recommended.

PART VII.

A Summary and a Review.

The series of researches herein summarized was commenced in March 1904, and has been carried on until the present time. The first part, containing the earliest results obtained, was read before the fifth West Indian Agricultural Conference at Trinidad in January 1905. The results were subsequently published in the *West Indian Bulletin* (Vol. VI, pp. 52-60). Part II was published in the *West Indian Bulletin* (Vol. VII, pp. 132-40). Part III would have been read before the sixth West Indian Agricultural Conference in Jamaica in January 1907 and was published in the *West Indian Bulletin* (Vol. VIII, p. 111-9).

The remaining three parts of the research have been recently read before the Society of Chemical Industry at London, and abstracts of them have been given above. It was thought that the papers were too technical to admit of their inclusion in full in the *West Indian Bulletin.*

It is proposed that the present paper should summarize as far as possible, the objects and main results of the work accomplished and, at the same time, briefly review the present position in regard to the subject, which is still, to a certain extent, controversial.

The subject-matter falls naturally under four heads: (1) the influence of temperature on the specific rotation of sucrose; (2) the effect of clarification with basic lead acetate on the polarimetric reading of commercial sugar solutions: (3) some suggestions for the modification of Clerget's method for the determination of sucrose by inversion; (4) some observations on the keeping power of Fehling's solution; together with notes on the volumetric process of determining reducing sugars with it.

Of the six papers referred to above four have a direct bearing on the simple direct polarimetric reading of a commercial sugar solution as a measure of the sucrose contained in it. It is true that this process is, at best, of only approximate accuracy, and that under certain conditions the value obtained may differ from the actual sucrose content by a very considerable amount. Nevertheless it is on this basis that practically the whole of the sugar consumed in the New World, and

a considerable portion of that consumed in the Old, is bought and sold. Probably a fair estimate of the amount of sugar which annually changes hands on the basis of this test would be about half of the total sugar crop of the world, or some 5,000,000 to 6,000,000 tons.

On this account, it becomes a matter of prime necessity, that the conditions under which the determination is carried out should be as accurate as possible, and it is of paramount importance that standard methods of performing the test should universally prevail in order that any two analysts situated in any part of the world shall be able, when working under these conditions, to obtain identical values for identical samples. The importance of this latter point becomes especially great in the case of countries, such as the United States of America, where heavy import duties are imposed on sugars entering, frequently amounting to a very considerable fraction of the market value of the sugar itself.

Notwithstanding these facts, it is more than probable that considerable differences exist at the present time between the methods employed by different analysts, and in many cases the methods used would appear to involve appreciable errors in the determination.

Strenuous efforts are at the present time being made to remedy this defect, and the work of the International Commission for Uniform Methods of Sugar Analysis has done much toward securing this end.

In summarizing the results arrived at by us, the first subject to be considered will be the question of the influence of temperature on the specific rotation of sucrose. The question is dealt with in the first half of Part I of this series of papers (*West Indian Bulletin*, Vol. VI, p. 52), and in Part II (*West Indian Bulletin*, Vol. VII, p. 132).

It is some twenty-five years since the earliest instance of allowance being made for the influence of temperature on the specific rotation of sucrose in practical saccharimetry was recorded.

We are informed, on the authority of Professor J. B. Harrison, that in the year 1882, it became the practice of his predecessor in Demerara, Professor E. E. H. Francis, to allow a correction of 0·3° Ventzke for the effect of tropical temperature on the specific rotation of sucrose, when polarizing commercial sugars.

Since that time, a storm of controversy has raged round the question of the existence or otherwise of this effect. This was particularly so between the years 1899 and 1903, at the time of the celebrated United States trial in which the American Sugar Refining Company contested the legality of the United States Government applying a correction for this effect when polarizing sugars for the assessment of import duty payable thereon.

Alteration of temperature is liable to affect the polarimetric reading of sugars in a variety of ways: by causing alteration of dimensions in polarimeter tubes and flasks, by

altering the volume of the solution, if the temperature of polarization differs from the temperature at which it is made up, by affecting the specific rotatory power of quartz, which forms an essential part of the most commonly employed forms of saccharimeter, and lastly, by affecting the specific rotation of sucrose itself.

Concerning the first three of these points there is absolute agreement, but concerning the effect of temperature on the specific rotation of sucrose much discussion has taken place in the past.

In view of the considerable importance of this point, and of the conflicting nature of the evidence available concerning the existence of the effect, we endeavoured to satisfy ourselves concerning the question.

Our earliest experiments consisted essentially in the polarization, at tropical temperature and under standard conditions, of a normal weight of chemically pure sucrose dissolved in 100 true c.c. of water.

As the upshot of these experiments we made the following recommendation :—

'Polarize at the temperature at which the solution is prepared, and correct for temperature by the formula N + ·00039 t N, where t is the difference between the temperature of observation and that at which the instrument was standardized, and N is the observed polarimeter reading. (*West Indian Bulletin*, Vol. VI, p. 54.)

This correction includes the correction for the effect of temperature on the quartz of the quartz wedge of the polarimeter and on the specific rotation of sucrose.

These earlier observations aroused a certain amount of criticism, the main point of contention being that the correction proposed by us presupposed that the specimen of sucrose employed was absolutely pure—a point difficult of proof.

For this reason, it was decided that further experiments were required for the elucidation of this point. In order to obtain a method of attacking the problem in which the presence of small amounts of impurity in the sample may be neglected, it is only necessary to observe the optical rotation of an approximately pure solution of sucrose at two differing temperatures, and to compare the results. This method of solving the problem presents special difficulties in the tropics, though it is more easy of attainment in a cold climate.

In the winter of 1905, however, the presence in England of one of us (H.A.T.) rendered possible this method of attacking the problem, and a series of experiments on the above lines was carried out, thanks to facilities afforded us through the courtesy of Messrs. Garton, Hill and Company, of Battersea, London, and of their chief chemist, Dr. L. T. Thorne.

As a result of this second series of experiments, we modified our original recommendations as follows :—

Polarize at the temperature at which the solution was prepared and correct for temperature by the formula N +

·00031 t N (*West Indian Bulletin*, Vol, VII, p. 140). This value, as will be seen, is somewhat lower than that originally proposed. The difference between the two values we attribute to a small amount of impurity in the sucrose originally employed.

This second result is in almost absolute agreement with those obtained by other workers in the same field. Of these may be cited those of Wiley in the United States of America, Schönrock in Germany, Harrison and Douglass in Demerara, and, more recently, Prinsen Geerligs in Java. All of these workers have found an effect for rise of temperature, on the quartz wedge of the saccharimeter and on the specific rotation of sucrose amounting to ·03° Ventzke for a normal weight of pure sucrose for a rise of temperature of 1° C.

Having regard, therefore, to the mass of affirmative evidence, there can be no doubt at the present time concerning the existence of the effect, which is, we think, almost universally conceded; but regarding the means to be adopted in allowing for the effect in practice, some divergence of opinion at the present time exists.

The International Commission for Uniform Methods of Sugar Analysis, at their session held in Paris on July 24, 1900, recommended that all sugar tests should be made at the temperature of standardization of the polarimeter, as by this means all necessity for correction for temperature is avoided.

They advocated the alteration of the temperature of standardization for polarimeters from 17·5° C. to 20° C., the universal employment of the true cubic centimetre for graduation of flasks, etc., employed, and the alteration of the normal weight from 26·048 grammes to 26 grammes.* For those countries which possess an average temperature differing from

* It may be here pointed out that for a number of years the definition of the normal sugar solution for the Ventzke scale has been as follows:—'That sugar solution has the normal strength which contains at 17·5° C. in 100 Mohr cubic centimetres 26·048 grammes of sugar weighed in air with brass weights.' (Landolt, *Optical Rotation of Organic Substances*, 2nd American Edition, 1902, p. 373.) The Mohr cubic centimetre is the volume occupied by 1 gramme of distilled water at 17·5° C. weighed in air with brass weights. The true cubic centimetre, the adoption of which has been advocated by the International Commission, is the volume occupied by 1 gramme of water weighed in vacuo at 4° C.: 100 c.c. Mohr are equal to 100·234 c.c. true, and an exact conversion of the normal weight of 26·048 grammes in 100 c.c. Mohr to true c.c. is 25·988 grammes. This amount, weighed in air with brass weights and dissolved in 100 true c.c. of distilled water at 17·5° C. gives a solution of the normal concentration. If the recommendation of the International Commission is followed, and the standard temperature is fixed at 20° C., allowance has to be made for the influence of temperature on the specific rotation of sucrose in rising from 17·5° C. to 20° C., and this would raise the normal weight from 25·988 grammes to 25·999 grammes. If further allowance is made for the influence of rise of temperature on the quartz of the quartz wedge of the saccharimeter, this would raise the normal weight for true c.c. at 20° C. to 26·01 grammes.

It may be mentioned that the German Imperial Physical Technical Institute pointed out in 1898, that an exact conversion of the normal weight of 26·048 grammes for Mohr cubic centimetres at 17·5° C. corresponds to 26·01 (not 26·00) grammes metric volume at 20° C.

The recommendation of the International Commission, that a normal weight of 26·00 grammes should be adopted, at a standard temperature of 20° C., involves a very slight alteration in the Ventzke scale therefore.

20° C., the Commission decided that it was permissible that saccharimeters should be adjusted at any other suitable temperature.

Harrison, one of the earliest workers to produce accurate measurements of the effect, has stated his practice to be: to standardize polarimeters for tropical working by ascertaining by experiment the exact weight of pure cane sugar which is required to give a reading of 100° V. at the ordinary working temperature, and to employ this as the normal weight when working with that instrument.

Wiley, for the purpose of correcting the polarimeter reading for the effect, has constructed tables of correction-factors for addition to the observed reading. This practice we have followed ourselves during the past three years, as it has appeared to us to be the simplest, and to give the best results.

An argument that has recently been brought to bear against the correction of the polarimetric reading of *raw cane sugars* for the effect of alteration of temperature, is that they contain appreciable amounts of levulose, the specific rotation of which is affected by alteration of temperature to an extent far in excess of that experienced with sucrose. Moreover, this effect would operate in a direction contrary to that experienced with sucrose, and that consequently, correction for the one without allowance for the other will be productive of error.

This argument has been advanced by Dr. C. A. Browne, junior, formerly Chemist-in-charge of the Louisiana Sugar Experiment Station, and now Chief of the Sugar Laboratory of the United States Department of Agriculture, in a report on the investigations at the Louisiana Sugar Experiment Station laboratory for 1904 (*Louisiana Planter*, Vol. XXXII, p. 239).

While not disputing the accuracy of the statement concerning the effect of temperature on levulose, we would point out that the process of determining the polariscopic test of a sugar is purely arbitrary and conventional. We take it that the polariscopic test of any sample of sugar is the rotation produced by it when tested in such a way that a sample of chemically pure sucrose tested under precisely similar conditions would give a reading of 100°. The 100 point of the Ventzke, or any other sugar scale, is based on the rotation of a standard weight of sucrose, dissolved in a standard volume of water, at a standard temperature. If at any other temperature this weight of pure sucrose will not give a rotation of 100° on the scale, the scale has been altered: consequently allowance must be made for this alteration in the scale when polarizing commercial sugars under these conditions. This allowance may be effected either by changing the normal weight to suit the new conditions, or by making such addition to the observed reading under the conditions for which the polarimeter was standardized, as would be equivalent to making such an addition to the normal weight.

With raw and partially refined sugars, it is impossible to determine the polarimetric reading on the untreated solution, owing to the presence of various impurities which render the solution too dark to be read in the polarimeter. Under these

circumstances, it becomes necessary to clarify solutions for polarization by some means. This may be accomplished in a variety of ways, but that which has found by far the widest application, consists in the use of basic lead acetate as a clarifying agent either in the form of solution, or, according to the process recently introduced by Dr. Horne, in the anhydrous form as powder.

The second main question dealt with by us in these investigations has been connected with this question of clarification of raw cane-sugar solutions by means of basic lead acetate.

In Part I of these investigations we came to the conclusion, in common with other investigators, that when raw cane-sugar solutions are clarified with solutions of basic lead acetate, serious error is liable to be introduced into the determination by reason of the fact that the volume occupied by the precipitated compounds of lead and non-sugar results in the sugar itself being dissolved in less than the standard quantity of solvent, and hence the observed polarimeter reading is too high.

In order to ascertain the magnitude of the error involved in this way, a method was devised by us for measuring the volume occupied by the lead precipitates formed in clarifying raw cane sugars.

As a result of these experiments, we found that, for a normal weight of muscovado sugar, the volume occupied by the precipitate formed in the course of clarification with solutions of basic lead acetate, varied from 0·3 to 0·4 c.c., and polarizations of such sugar solutions, clarified in this way, might be expected to be too high by amounts varying from 0·25° to 0·35° Ventzke.

As a means of eliminating this error we advocated the employment of the method devised by Dr. W. D. Horne, whereby clarification is effected by means of the addition of solid anhydrous basic lead acetate to the sugar solution after it had been made up to bulk. By this means it is ensured that the sugar is dissolved in the correct amount of solvent, and is presumed that no appreciable change of volume of the solution occurs during clarification.

Experiments performed by us fully bore out the validity of these premises. It was shown that similar solutions of the same sugar gave lower polarimeter readings when clarified by this method than when clarified by means of basic lead acetate solution, by amounts that closely corresponded to the values calculated from a knowledge of the volume of the precipitates.

These results have given rise to a certain amount of criticism. Prominent among these critics have been the MM. Pellet, who have maintained that the dry defecation method is liable to occasional error. The reason assigned for this contention, is that the precipitate formed in lead clarification has the property of absorbing sugar from the solution. According to these workers, the amount of sugar absorbed in the case of sugar solutions clarified by means of solutions of basic lead acetate, is of such quantity as to neutralize exactly

the concentration-effect occasioned by the volume of the precipitate, and accordingly, on this account, the polarizations of commercial sugar solutions clarified in this manner are not in error. Hence, if this is so, it follows that the polarimetric readings of sugar solutious clarified with anhydrous lead acetate are too low.

These statements have been examined by Dr. Horne, who has found that the lead precipitate instead of absorbing sugar takes up a very small amount of water. We may add that in our experience we have been unable to find indications of such an effect as MM. Pellet suggest.

Apart from these considerations, clarification with basic lead acetate has been generally believed to possess fundamental inaccuracies owing to interaction of the lead salt with the various impurities occurring in commercial sugars.

Into these inaccuracies we set ourselves to enquire with a good deal of care. Chief among them is the action of basic lead acetate on invert sugar, or rather on the levulose thereof which results in the formation of soluble lead levulosates possessing optical rotating power differing from that of levulose itself by considerable amounts. Hence it is held that serious errors are likely to arise from the effect of any excess of basic lead acetate that may be in solution after clarification has been effected. The action of lead on levulose was first pointed out by C. H. Gill in 1871, and afterwards by Bittmann in 1880. Since then the subject has received little or no further investigation, though it is constantly alluded to in text-books, etc.

As the upshot of experiments, we found that small excesses of basic lead acetate had very little effect on the optical activity of solutions of invert sugar, although when the quantity employed was increased beyond excesses likely to occur in analytical practice, the effect became marked. Consequently we concluded, that when excess of lead acetate was avoided, the error likely to be introduced into the determination through the employment of this re-agent in consequence of its re-action with invert sugar, is negligible in the majority of cases.

This conclusion was tested and its validity borne out by observations on solutions constructed to represent actual commercial sugar solutions, but in which the actual amounts of the various constituents present were accurately known. In addition, these results bore out the conclusions of Horne regarding the non-absortion of sugar by the precipitate. By reason of these results it appears to us unneccssary to search for other and more complicated methods of clarification, for, using solid anhydrous acetate of lead, it is quite easy to obtain results which are well within the limits of accuracy of the ordinary methods of sugar analysis.

The subsequent parts of this portion of the work contained in the latter half of Part IV and in Part V of this series of papers are mainly concerned with the consideration of practical points arising out of actual experience with this method of clarification.

For information concerning these various points, the reader is referred to the abstracts of Parts IV and V given above.

The third subject which has claimed attention in the course of these investigations has been the Clerget process for determining the amount of sucrose present in sugars.

This process has for many years been recognized as the standard method for the determination of the actual sucrose contents of commercial sugars, and, when properly employed, is undoubtedly one of the most accurate processes in the whole of commercial organic analysis.

At the same time, for its successful application, it is necessary that the conditions under which the determination is to be performed should be rigidly observed, since the reduction-factor employed depends entirely on the conditions governing the performance of the determination. Failure to recognize this point must lead to erroneous results.

In Part III of this series of papers the process is considered and a modification, with special reference to tropical conditions, suggested.

The special features of the modification proposed by us are (1) working at a standard temperature of 30°C., and (2) the employment of lower concentrations of acid to effect the inversion than were employed in the older processes. By this means greater latitude in the time during which the sugar solution is heated to effect inversion, becomes allowable, and the risk of introduction of error from too high or too prolonged heating heating is minimized.

As a result of ten separate series of experiments we found, for the conditions stated above, a reduction-factor of 128·08 for a standard temperature of 30°C.

The more extended use of the Clerget method in sugar analysis is now largely advocated, and there can be no doubt that it would be a great advance in the direction of accuracy were it to replace entirely the simple direct polarization as a means of ascertaining the sucrose contents of saccharine products. At the same time, the facts that the Clerget process requires for its accurate performance a considerable amount of care and labour, and also occupies much more time than the simple direct polarization, renders it very unlikely that such a drastic change can ever come to pass completely. Moreover, it hardly appears likely that, at any rate in sugar house control work, the gain in accuracy experienced through such a change would be worth the additional expenditure of labour required.

On the other hand, there is no doubt that where the sucrose content of any saccharine product is required to be accurately known, the Clerget process should find universal employment.

The final part of the series of papers deals with the determination of sugars by means of Fehling's solution. Strictly speaking, this part of the research cannot be said to be directly connected with polarimetric work, but it has been

included under the general title for convenience of reference, as the subject-matter is to a large extent connected with earlier portions of the work.

In it we have pointed out that, contrary to the commonly believed idea, Fehling's solution, or, at least, Violette's modification thereof, does not undergo rapid deterioration if it is kept in the dark and if access of air is prevented thereto. The solution can therefore be kept mixed ready for use, and it is not necessary to maintain the stock in the form of two solutions to be mixed as required.

The remainder of the paper is occupied with the discussion of various details connected with the volumetric process of determining reducing sugars, with special reference to the determination of the end-point of the reaction, and also to the reducing action of sucrose itself in determinations of this description. In this latter connexion results are adduced by us showing the order of magnitude of the effect involved, which is not negligible in practice, and suggestions are made for the correction of it in analytical work.

If due account is taken of these points, it is believed that the volumetric process for Fehling's solution is capable of being performed with greater accuracy than is generally credited to it.

SUMMARY OF CONCLUSIONS.

1. Rise of temperature effects a lowering of the specific rotation of sucrose, sufficiently large to affect appreciably the polarimetric readings of commercial sugars at tropical temperatures.

The combined effect for rise of temperature on the specific rotation of sucrose and on the quartz of the quartz wedge compensator of the saccharimeter may be stated to be as follows: $N + \cdot 00031tN$, where N is the observed reading on the Ventzke scale and t is the difference between the temperature of observation and that at which the polarimeter was standardized. In making polariscopic tests of sugars we have made the following recommendation concerning the effect of temperature, viz: Polarize at the temperature at which the solution was prepared and correct for temperature by the above formula.

2. If commercial sugar solutions are clarified for polarization by means of basic lead acetate solution, error is introduced into the determination by reason of the displacement volume of the precipitate formed. This error is avoided by the employment of anhydrous lead acetate as clarifying agent (Horne's method). If care is taken to avoid large excess of this re-agent, its use does not affect the accuracy of the determination to any appreciable extent. Moreover, owing to the reduction in the number of measurements of volumes of liquids requiring to be performed, the employment of the reagent is more simple in practice than the older method.

3. For the accurate determination of the actual amount of sucrose present in a commercial sugar, the Clerget process is to be recommended. In the process described by us the acid

used is more dilute than in any of the older processes, and greater variation in the length of time occupied in heating is permitted thereby. For these conditions we have determined the factor to be 128·08 for 80°C.

4. (*a*) Violette's modification of Fehling's solution does not undergo rapid deterioration if kept in the dark and if access of air is prevented thereto.

(*b*) It is necessary and desirable to make due allowance for the reducing action of sucrose itself when making determinations of reducing sugars by means of the volumetric process for Fehling's solution.

(*c*) If the above point is observed, and if a suitable process is employed for determining the end-point of the reaction, the volumetric process for Fehling's solution is capable of considerable accuracy.

ESTABLISHMENT AND WORKING OF THE SUGAR INDUSTRY AGRICULTURAL BANK AT BARBADOS.

BY THE HON. F. J. CLARKE, C.M.G., M.A.,

President of Barbados Agricultural Society.

In giving a short account of the establishment and working of the Sugar Industry Agricultural Bank, it will be interesting to trace the steps that have been taken from time to time to enable planters in this island to obtain advances for carrying on the working of their plantations. As long as sugar brought a good price and there was a good margin of profit there was practically no difficulty in obtaining advances, but with the drop in the price of sugar in 1884, there were many whose estates were encumbered who found themselves in difficulties. As owners of encumbered estates they could not pledge the crops for advances, and no one was willing to take the risk of advancing against the crops of encumbered estates, as the lien holders might foreclose before the reaping and sale of the crops.

In July 1885, Sir W. Robinson, who was then Governor, in a minute to the Colonial Secretary stated that he had been informed that certain planters were unable to obtain a supply of necessaries for cultivation during that season without temporary assistance, and that he would be glad to have some reliable information as to whether this was true, and suggested that a joint Committee of both Houses of the Legislature be appointed to enquire into and report on the matter; and that were it true, the Committee would doubtless consider the propriety of passing a temporary enactment giving preference to charges on the next crop for cultivation advances within certain limits. This minute was laid before the House of Assembly and the joint Committee was appointed.

They reported to this effect:—

That the owners of plantations in this island may be divided into three classes as follows:—

1. Those who cannot be said to need assistance.
2. Those who are quite insolvent and could not be judiciously assisted.
3. An intermediate class, but the Committee could not agree as to whether this was a large or a small class.

And that they were not in favour of recommending any such legislation as that suggested by his Excellency.

A member of the House gave notice of his intention to move the House into Committee on some future day to discuss the general question embodied in the report. At a subsequent meeting he moved that the House go into Committee to consider the question of raising a sum not exceeding £100,000 to assist planters to bring their crops to maturity. This motion was very fully discussed, but was lost.

The difficulties of planters increased meanwhile, and in the following year, 1886, an Act was passed entitled 'an Act to enable sugar plantations to be cultivated and managed for a limited period,' and was generally known as the Plantations-in-aid Act, 1886. It was to remain in force for one year. It provided for a Government guarantee of advances against the crops of the following year.

Three Commissioners were to be appointed by the Governor-in-Executive Committee, whose duties were to determine what advances should be made to each person applying, to see that the money advanced was properly expended, and that the proceeds of the crops against which advances had been obtained were handed over to the persons making the advances. Any unpaid balance was to be a charge against future crops, and at the back of all was the Government guarantee. Proceedings in the Court of Chancery did not affect the security given by the Act over the crops against which advances had been made.

The Secretary of State for the Colonies did not approve of the revenues of the island being pledged for the purposes of the Act, but considering the circumstances under which it had been passed he said he would not advise Her Majesty to disallow it. This Act never came into operation. The troubles of planters were increasing at a rapid rate and many plantations were thrown into Chancery. And in the following year, 1887, another attempt was made to solve the difficulty by the passing of the Agricultural Aids Act. This Act provides that owners may obtain advances on the security of their crops. Owners intending to obtain advances must advertise their intention to do so, and if within a certain time the lien holders do not object, they may do so under the provision of the Act. The security over the crops, which they are thereby empowered to give, is not affected by a foreclosure suit. Future crops are not liable for unpaid balances. The security is over the one year's crops pledged, and those alone.

This Act, which is still in operation, enabled planters to carry on with more or less difficulty according to the seasons until the severe crisis in 1902. Early in that year planters were informed by those who had been making them advances under this Act, that they were not prepared to make any further advances owing to the very hopeless outlook for the sugar industry. Strong representations were made to Mr. Chamberlain as to the perilous state of the sugar industry in the West Indies and British Guiana, and he got a free grant of £250,000 from the British Government to assist planters in tiding over the time that should elapse before the abolition of the bounties on beet sugar. The share of the grant allotted to Barbados was £80,000.

It was very wisely decided not to divide it up between the sugar growers, but to use it for the purpose of enabling the Government to make advances to them, to assist in carrying on the cultivation of their plantations.

To give effect to this wise decision an Act was passed entitled, The Plantations-in-Aid Act, 1902. The £80,000 was

placed under the control of the Governor-in-Executive Committee. The Act provides that the Executive Committee may borrow a sum not exceeding £200,000 at 5 per cent., on the security of the revenues of the island, to be repaid on August 31, 1903. The grant of £80,000 was to be used for the repayment of the money so borrowed. Five Commissioners were appointed whose duty it was, to receive applications for loans, and to recommend to the Executive Committee to whom loans should be made and the amount of such loans, to see to the proper application of the loans and their repayment. The loans were a speciality debt, the first lien against the plantation and against the crops and stock, and interest at the rate of 5 per cent. was charged on the loans.

The proceeds of the crops were to be paid to the Executive Committee, and if they were insufficient to repay the loan, the balance was to be repaid by five annual instalments with interest.

An owner before borrowing, had to obtain the consent of the lien holders against his plantation, or put an advertisement in the *Official Gazette* and one daily newspaper, of his intention to borrow.

Planters gladly availed themselves of this means of getting money to work their plantations, and loans to the amount of £96,041 were obtained by 122 planters for this purpose.

The Act was renewed in 1903, and 137 owners borrowed £151,806.

The Act was again renewed in 1904, and 109 owners borrowed £114,915.

In 1905, the Act was again renewed, but the provisions pledging the revenues of the island for the amount borrowed was omitted, and the loans to planters were made re-payable in four years at the request of the Secretary of State, who in his despatch on the subject said, that if the Act were to be renewed again, the period of re-payment must be further curtailed, viz:—from four years to three years, and from three years to two years and so on, so that all the loans may be repaid at latest in 1909. In 1905, 102 owners borrowed £99,807.

In 1906, the Act was again renewed for one year, and ninety-eight owners borrowed £112,540. As the time was approaching when the operations of these Acts would cease, and as it was necessary to devise some other scheme by which the £80,000 could be used for the same purpose, a Committee was appointed by the the Legislature to inquire into and report on the matter, and to recommend a scheme to take the place of the Plantations-in-Aid Acts when the same should expire in 1907. The Committee carefully considered the question, and by way of report handed in a Bill providing for the establishment of an Agricultural Bank. This Bill was approved of by the Executive Committee and was passed by the Legislature, becoming the 'Sugar Industry Agricultural Bank Act, 1907.' In the preamble it is stated, and whereas the system of making advances for sugar

cultivation, which has been in force since 1902 under the aforesaid Plantations-in-Aid Acts appears to be best calculated to promote the collective and permanent interest of the sugar industry, and it is desired to place that system on a permanent footing by transferring the free grant of £80,000 made to the Barbados Sugar Industry in 1902 with accrued interest, and the securities therefor, to a Sugar Industry Agricultural Bank to be established for the purpose of continuing such advances to sugar producers.

The Act provides for the formation of the Bank.

The Colonial Secretary, one person to be appointed by the Legislative Council, four persons to be appointed by the House of Assembly, and one person to be appointed by the Agricultural Society are made a body politic and corporate under the name of 'The Sugar Industry Agricultural Bank.' These persons are called the members of the Bank. The Colonial Secretary is the Chairman.

The grant of £80,000 and all accretions of interest which amounted to £16,360 *5s. 8d.*, and all securities for amounts still due by plantations are vested absolutely in the Bank.

All the provisions respecting the making of loans, the expenditure and re-payment thereof, are the same as those of the Acts prior to the Act establishing the Bank.

All unpaid balances of advances against a crop are made re-payable in five annual instalments with interest.

The Bank takes the business of advancing to planters out of the hands of the Executive Committee, thereby putting an end to all Government connexion with this business. Since the establishment of the Bank early last year, it has lent £68,443 to ninety-three sugar producers.

When the Bank took over this business there were £13,980 due for advances made in 1902 against the crop of 1903—a short crop with low prices; £263 due for those of 1903 against the crop of 1904, £487 due for those of 1905, and £938 for those of 1905 against the crop of 1906. These balances are being gradually paid off.

The only loss was in 1903, and that amounted to the insignificant sum of £250.

Planters were enabled to pass through the severe crisis of 1902, and those who have chosen to do so, have continued to work their plantations by availing themselves of the opportunities afforded by the Bank for obtaining advances. But for the timely aid rendered by the grant of £80,000 and the passing of the Plantations-in-Aid Act of 1902, there would have been a state of things in this island which one dreads to contemplate.

As will be seen from the short account I have given, this is not an Agricultural Bank in the sense in which institutions in Germany and other parts of the world are known as Agricultural Banks, but it has suited the conditions surrounding the sugar industry in this Island, and I venture to predict a career of usefulness and prosperity.

DISCUSSION.

Mr. J. H. Collens (Trinidad) said that this Bank seemed to have been established upon quite a different principle to the Raiffeisen banks in Europe, and would seem to be intended to benefit only one class of persons, namely the sugar planters who had not sufficient funds of their own to bring their crops to maturity. In Trinidad and some of the other islands an Agricultural Bank would have to be of a more general character. He should like to know on what basis they went in determining the amount of loan to be advanced to any particular planter, and whether the loans could be extended to other industries.

Hon. F. J. Clalke explained that the sugar industry was, in 1902, the only industry in Barbados, and the Imperial Grant of £80,000 was given to sugar growers and it was specially stipulated that it was to be used for the permanent and collective benefit of the sugar industry. Applications for advances were sent to the Directors of the Bank and they decided how much should be lent to each particular planter. The planter made a return of the amount of crop he intended to cultivate, the acreage of his plantation and so on, and the Directors of the Bank decided what loan it would be safe to make on the crop and plantation, basing their decision on the number of acres of land and so on.

With regard to making advances to other than sugar producers, the members of the Bank tried to be as liberal as possible. If a planter wanted advances on what was practically a cotton plantation they insisted that he must also have some sugar-cane growing, so as to come within the four corners of the Act. It did not matter what was the area he had planted in canes. He might have a plantation containing 50 acres of land, of which 49 acres were planted in cotton and 1 acre in sugar. That would meet the requirements and justify a loan.

CACAO INDUSTRY.

RESULTS OF THE RECENT EXPERIMENTS WITH CACAO IN THE WEST INDIES.

DOMINICA.

MANURIAL EXPERIMENTS.

BY FRANCIS WATTS, C.M.G., D.SC., F.I.C., F.C.S.,

Government Chemist and Superintendent of Agriculture for the Leeward Islands.

EXPERIMENTS AT BOTANIC STATION.

The experiments conducted by Mr. Joseph Jones at the Botanic Station Dominica, have been carried on for a number of years on uniform lines and furnish information of considerable value.

They consist of five plots, each of approximately ¼ acre which since 1900 have annually been manured as follows:—

Plot No. 1 ...	No manure.
„ No. 2 ...	4 cwt. basic phosphate, 1½ cwt. sulphate of potash, per acre.
„ No. 3 ...	4 cwt. dried blood per acre.
„ No. 4 ...	4 cwt. basic phosphate, 1½ cwt. sulphate of potash, and 4 cwt. dried blood, per acre.
„ No. 5 ...	Mulched with grass and leaves.

The yield of cacao has been recorded since 1902-3, and the results are summarized in the following table:—

YIELD OF CURED CACAO IN POUNDS PER ACRE.

Year.	Plot 1. No manure.	Plot 2. Phosphate and potash.	Plot 3. Dried blood.	Plot 4. Dried blood, phosphate and potash.	Plot 5. Mulched with grass and leaves.
1902-3	1,138	1,540	1,491	1,599	1,300
1903-4	822	1,170	1,132	1,069	1,092
1904-5	1,009	1,179	1,132	1,418	1,338
1905-6	1,122	1,105	1,231	1,506	1,724
1906-7	1,095	1,285	1,134	1,461	1,743
Total for five years.	5,186	6,279	6,279	7,053	7,197
Average for five years.	1,037	1,256	1,224	1,411	1,439

The results clearly show the value of manures for cacao. During five years, the use of phosphate and potash has increased the yield of dry cacao 219 lb. per acre per annum over the yield of the plot receiving no manure. Similarly, the use of dried blood, primarily a nitrogenous manure, has increased the yield by 187 lb., while the combination of the two sets of manures (i.e, phosphate, potash, and dried blood) has increased the yield by 374 lb. The mulching has shown the greatest gain, namely 402 lb. per acre per annum.

By putting the moderate valuation of 6*d.* per lb. on cured cacao, a figure much below market value, we may obtain an idea of the monetary aspect of the case :—

Plot.	Average annual yield per acre of cured cacao during five years, in pounds.	Gain in dry cacao per acre over no-manure plot, in pounds.	Value per acre of increase over no-manure plot, at 6*d.* per lb. of cured cacao.	Cost of manure, per acre.	Gain per acre by manuring.
			s. d.	s. d.	s. d.
1	1,037	...	...	...	...
2	1,256	219	109 6	45 3	64 3
3	1,224	187	93 6	36 0	57 6
4	1,411	374	187 0	81 3	105 9
5	1,439	402	201 9	60 0	141 0

The above figures hardly do full justice to the full gain resulting from mulching, the results of which are only apparent after some time. It is interesting therefore to make a comparison based on last year's crop only :—

Plot.	Yield per acre of cured cacao, in pounds. 1906-7.	Gain per acre over no-manure plot, in pounds.	Value per acre of increase over no-manure plot.	Cost of manure, per acre.	Gain or loss per acre by manuring. 1905-6.
			s. d.	s. d.	s. d.
1	1,095	...	...	...	...
2	1,285	190	95 0	45 3	+ 49 9
3	1,134	39	19 6	36 0	− 16 6
4	1,461	366	183 0	81 2	+ 101 6
5	1,743	648	324 0	60 0	+ 264 0

The last two tables should be studied together.

The mere consideration of the yield of cacao does not fully explain the condition of the plots and the changes taking place thereon.

When the general health and growth of the trees on the plots are taken into account, it is at once seen that the individual trees on the mulched plot are much finer and are better developed than those on the other plots : the soil also is better than that of any other plot. It is moist, friable, and full of humus, and in a better condition generally, which would appear to ensure good crops for some time to come. It is also significant that this plot is well covered by trees planted at the rate of 108 per acre, while the plot receiving no manure requires 178 trees per acre, or nearly 70 per cent. more.

Next in general health and condition may be placed plot 4, which received phosphate, potash, and dried blood. This plot requires at the rate of 124 trees per acre to cover it. The number of trees on the other plots is as follows, plot 3, 139 trees per acre ; plot 2, 155 trees per acre ; and plot 1, 178 trees per acre.

As the general result of these experiments, planters are recommended to manure their cacao trees.

Organic manures such as pen manure and liberal mulchings are doubtless the best and most remunerative. Where these cannot be obtained in sufficient quantity, it is essential to give manures containing nitrogen and phosphate, and in many cases it will be well to supplement mulching with moderate applications of nitrogen and phosphate.

Phosphate may be given with advantage in the form of basic phosphate in applications of from 1 to 4 cwt. per acre. A sufficient application in most cases will be 1 cwt. per acre annually for several years.

Nitrogen may be given in the form of sulphate of ammonia at the rate of from 1 to 2 cwt. per acre, but nitrogen should be given preferably in a form in which it is more slowly available, such as dried blood, at the rate of 2 to 4 cwt. per acre.

With the development of the cotton industry in these islands considerable quantities of cotton-seed meal may be within reach. This forms a very useful source of nitrogen, and may be used at the rate of from 3 to 6 cwt. per acre. It introduces fair quantities of phosphate and potash, as well as nitrogen.

The present experiments afford no evidence as to the value of potash and phosphate independently of each other. The soils of Dominica are, however, fairly well supplied with potash, and it is not likely that this constituent is urgently wanted. In the event of planters desiring to experiment with potash, it is believed that small dressings of from ½ to 1 cwt. of sulphate of potash will prove sufficient.

GOVERNMENT PLOT AT PICARD.

This plot was started in 1900, in order to ascertain whether cacao could be grown on the low lands at Picard. At the time the plot was laid out, the general opinion was that this district was not suitable for cacao. Largely as the result of the success of these experiments, considerable areas of cacao have been planted in the neighbourhood, and the success attending the newly established fields justifies the action. This area is now regarded as one of the most promising cacao districts in Dominica.

The plot consists of 1 acre, divided into four sections. In the early stages the whole of the plot was manured with pen manure and dried blood. In 1903, the area was divided into four plots, each of ¼ acre as follows :—

A. receiving pen manure.
B. receiving 2 cwt. per acre of sulphate of ammonia.
C. receiving 4 cwt. per acre of basic phosphate.
D. receiving 4 cwt. per acre of dried blood.

These manures are applied annually.

The southern part of plot D is found to rest on a gravelly substratum : probably the old river bed extended to this point. From 1905, this poor portion has been dressed with pen manure, in an attempt to restore fertility.

The first small pickings were gathered in 1904-5. The yield from the plots have been :—

Plot.	Number of pods. 1904-5.	Number of pods. 1905-6.	Number of pods. 1906-7.	Equivalent to dry cacao in 1906-7, in pounds.
A.	8	319	883	68
B.	1	235	598	46
C.	13	390	733	60
D.	6	133	493	38
Total	28	1,077	2,747	212

The trees receiving pen manure have a very fine and healthy appearance, and they have given the largest yield of cacao.

The trees receiving sulphate of ammonia also present a very fine healthy appearance but they have not yet come into such heavy bearing as the trees receiving either pen manure or basic phosphate.

The plot receiving basic phosphate has given a large return, and the trees look in excellent condition. The foliage

is perhaps not so heavy as in the plots receiving pen manure or ammonia. The plot experienced no lack of nitrogen, as it has received a large amount of green dressing from the careful management of the weeds which have grown upon it and have been turned in. The plot does not show indications of falling off such as are referred to in connexion with the basic phosphate plot in the larger series of experiments at Picard. It must, however, be remembered that this plot, with the others, received good dressings of pen manure and dried blood in the first two years of its existence.

The dried blood plot, as explained above, is rather uneven but there are some good trees upon it.

These four plots have been carefully worked on the system which involves the careful use of weeds as green dressings. The growth of the weeds has been watched, and as soon as they reach a moderate size they are cut down and either spread as a mulch or forked in (see 'Manurial Value of Weeds in Cacao and Lime Orchards,' *West Indian Bulletin*, Vol. V, p. 287).

The results obtained on these plots, and the excellent condition of the soil, would appear to show that while pen manure, when available, is most valuable in cacao orchards, still the condition of the soil can be maintained and improved by judicious green dressing with weeds. The experiments should be continued for some years, for it will be interesting to see if the fertility of plots B. and C., receiving part of manures with ammonia and phosphate respectively, will be maintained without any other application.

LARGER MANURIAL EXPERIMENTS AT PICARD.

The experiments conducted in co-operation with Mr. Sowray the representative of Messrs. Rowntree & Co. have given interesting results. These consist of twelve plots. Each plot, which is ¼ acre in extent, contains sixty-four trees, and is separated from its neighbour by two rows of cacao trees. Plots 3 and 6 are separated from 7 and 10 by three rows.

Measured by the number of pods produced, the results show in an unmistakable manner that manures are beneficial and remunerative in the establishment of young cacao. Judged on this basis, it is seen that pen manure has given the best results, the yield of pods this season from this plot being two and a half times that of the plot without manure.

Dried blood has resulted in large returns and so has bone meal.

Each of the constituents of manures [phosphate, potash, and nitrogen (as ammonia)] has increased the number of pods in a marked degree, and this has been the case whether these constituents have been used singly or grouped in various ways.

Plot 3, receiving potash only, has given an abnormally high yield and must be disregarded for the moment.

Plot 2 shows a considerable increase of crop as the result of the use of basic phosphate; plot 6 shows that the crop is only slightly increased by the addition of potash; while plot 4 shows that the addition of ammonia considerably increases the yield.

For easy comparison the results may be arranged as follows:—

Plot.	Manure.	Number of pods per plot.	Gain over no-manure plots in pods.	Yield in terms of dry cacao per acre in pounds.
Plot 12	No manure	740	—	228
„ 9	Compost	704	36	218
„ 1	Bone meal...	1,742	1,002	530
„ 2	Basic phosphate	1,179	439	362
„ 4	Basic phosphate and ammonia	1,596	856	490
„ 6	Basic phosphate and potash	1,184	444	264
„ 3	Potash	1,727	987	562
„ 5	Potash and ammonia ...	1,619	879	498
„ 10	Ammonia	1,160	420	356
„ 11	Basic phosphate, potash, and ammonia	1,488	748	458
„ 8	Dried blood	1,644	904	506
„ 7	Pen manure	1,871	1,131	576

The above conclusions are confirmed by the comparison of plots 10, 11, and 12. The addition of ammonia to plot 10 has greatly increased the yield as compared with plot 12 receiving no manure, while plot 11, receiving phosphate and potash in addition to nitrogen, shows a still further increased yield, due most probably to the phosphate. Further confirmation is obtained from plot 1, which received bone meal. Bone meal contains both phosphate and nitrogen. This plot has given a very large return. These facts go to prove that nitrogen and phosphate are the constituents most required while the effect of potash is doubtful.

The best returns of all are obtained from the use of pen manure which contains nitrogen, phosphate, and potash, and in addition, large quantities of organic matter. This latter substance greatly improves the texture of the soil and so adds very materially to its fertility. Dried blood has also given good results. This manure contains nitrogen, phosphate and potash, with organic matter. The general results with compost, plot 9, have not been satisfactory; either the compost has not been sufficient, or it is unexpectedly slow in its action.

Estimating the effect of manures on young cacao trees by taking account only of the yield of cacao is likely to be fallacious for more than one reason. In the early stages, there is likely to be irregularity in the manner in which young trees come into bearing, while some manures may tend to force the trees into early bearing and lead to early exhaustion. It is therefore, necessary to add to the statement of the yield of cacao, observations as to the general condition of the trees. When this is done in connexion with these experiments, we arrive at very interesting results.

The plots may be roughly grouped according to the health and vigorous appearance of the trees:—

(1) Very vigorous, with fine healthy foliage and robust trees.	Plot 7. Pen manure.
(2) Good, with healthy foliage and robust trees.	Plot 8. Dried blood. Plot 1. Bone meal. Plot 10. Ammonia. Plot 5. Ammonia and potash.
(3) Fair.	Plot 4. Ammonia and phosphate. Plot 11. Ammonia, phosphate, and potash.
(4) Lacking vigorous growth, foliage poor.	Plot 9. Compost. Plot 2. Phosphate. Plot 3. Potash. Plot 6. Phosphate and potash. Plot 12. No manure.

Judged by the appearance of the trees, we get a great deal of light thrown on the effect of manures. The best results, taking both the vigour of the trees and the yield of cacao into account, have been given by the use of pen manure. The yield is the highest of all the plots and the trees are the most vigorous. Next to this, we must place the bone meal, and the dried blood plots. Both these manures convey to the soil, nitrogen and phosphate. Following these, come plot 10, ammonia, and plot 5, ammonia and potash, and then plot 4, with ammonia and phosphate, and plot 11, with ammonia, phosphate, and potash.

After these, we come to a group where the trees obviously lack vigour and where we may soon look for a decided falling

off. The striking feature in this group, is that none of the plots have received any nitrogenous manure. It is to be noted that this group includes plot 2, phosphate, plot 3, potash, and plot 6, phosphate and potash, all of which have given good numbers of pods, and which, judged from the crop return alone, would be regarded as satisfactory. They cannot be regarded as satisfactory, however, and a falling off in crop is anticipated. The group includes plot 9, compost, and plot 12, no-manure.

The lessons from these experiments already begin to be valuable and may be summarized thus :—

Manures are useful in establishing cacao fields. Pen manure, when obtainable, is likely to give the best results.

Efforts should be made to increase the humus in the soil as much as possible. Manures supplying organic matter are desirable as they tend to maintain the supply of humus. Nitrogenous manures are essential; without nitrogen the trees lack vigour. Phosphatic manures increase the crops, but should not be used without nitrogen. It would probably be good policy to use nitrogenous and phosphatic manures together. The effect of potash is not very clear. It is probably not at present urgently required as a manure.

It is recognized that some of the plots are not likely to improve under the manurial treatment they are receiving, but their retrograde movement, should it occur, will throw valuable light on important points bearing on the manuring of cacao. This will entail some loss upon owners, but it is hoped this prospective loss may be faced for the sake of the valuable information likely to be obtained.

It should be observed that these experiments are carried on in a field where Mr. Sowray is putting into practice the suggestions to use weeds intelligently so as to increase humus. The weeds are allowed to grow to a moderate height and are then either cutlassed down, or bedded in with the fork as occasion requires. The general results have been very good and the field is improving steadily. When it was first laid out, attempts were made to keep weeds down thoroughly (clean weeding), and the soil was deteriorating. On altering the method of working, surprisingly good results followed.

DISCUSSION.

Professor J. B. HARRISON (British Guiana) asked whether these experiments had control plots among them.

Dr. WATTS said that if by control plots Professor Harrison meant plots receiving no manure, then there were control plots. In these experiments, the cacao trees were planted from 15 to 20 feet apart, and each plot was separated by at least two intervening rows of trees. Plots 3 and 6 were separated from 7 and 10 by three rows of trees. That, he thought, was as much control as could be expected upon any estate.

Hon. G. W. HAZELL (St Vincent) asked whether in mulching cacao trees with leaves and weeds, and grass, the material was allowed to wither and dry, or was applied in the green state.

Dr. WATTS replied that it was purely a matter of convenience whether the material was buried in the green state or allowed to lie on the ground and wither, and then subsequently turned in. In most cases the mulch was allowed to rot upon the surface of the ground.

Mr. E. A. AGAR (Dominica) inquired whether as the result of these experiments Dr. Watts was in a position to say that the application of manures had any appreciable effect on the cacao trees—did it increase their size, was there a difference in the weight of the pods or in the weight of the beans.

Dr. WATTS said that the relationship between manures and the size or weight of pods or the size of the beans was in need of investigation. No reliable information had, as yet, been obtained.

The PRESIDENT suggested that this was a matter which practical cacao growers might endeavour to determine for themselves. Experiments might be undertaken to ascertain whether the manure had any influence in increasing the weight of the pod, or the weight of the bean.

Mr. J. H. HART (Trinidad) said that in Trinidad the average return was seven pods to 1 lb. of dried cacao.

Hon. W. GRAHAME LANG (Grenada) said that in Grenada the average return was 1 lb. of dried cacao from eleven pods.

Mr. A. R. C. LOCKHART (Dominica) said that the experiments conducted at the experiment station by Dr. Watts greatly benefited the planters in Dominica who were near to Roseau, and were therefore in a position to watch the proceedings there: but three-fourths of the cacao in Dominica was produced by peasant proprietors—people hardly above the social position of labourers, and who were unable to derive any definite advantage from the experiments carried on at the Station. At the inception of the Imperial Department of Agriculture, when the Dominica section was being organized, provision was made for the appointment of an Agricultural Instructor whose duties were to travel around the country, and, by personal advice to the peasant growers, lead them to improve their methods of cultivation. He regretted, however, that at the present moment they had no Agricultural Instructor in Dominica. Since Mr. Branch had been removed to Grenada, the post of Agricultural Instructor had remained vacant. This was detrimental to the interest of cacao cultivation in Dominica, especially amongst the peasant proprietors Of course, he knew that there were considerable difficulties in the selection of an Instructor for an island like Dominica. It was necessary to find a planter competent to teach, but it was also necessary that he should be acquainted with the language of the people. He hoped, however, that the Imperial Commissioner would see his way at an early date to supply Dominica with the services of an Agricultural Instructor. The peasant

proprietors of Dominica deserved much recognition, because the cacao industry of that island was largely due to their efforts, and he could testify to their readiness to receive instruction and advice from the officers of the Imperial Department of Agriculture.

The PRESIDENT said that the subject which Mr. Lockhart had brought before the Conference was a very important one. Under existing circumstances the appointment of an Agricultural Instructor for Dominica was a very important matter. For two years a vote for an Agricultural Instructor at Dominica had appeared on the Estimates, and advertisements had continuously been issued for candidates for the post, but unfortunately, they had received applications from no one that could be considered entirely suitable. Mr. Lockhart, Mr. Agar, and other gentlemen connected with Dominica were doubtless well aware of the fact that, in every address he had delivered in Dominica, he had urged the claims of the small proprietors. Not only in Dominica was the post of Agricultural Instructor vacant, but it was also at the present moment vacant in St. Lucia. There again he had made the fact of there being a vacancy known, but so far, no candidate had applied for the post. Fortunately, in other colonies, Agricultural Instructors were available. The difficulty both in Dominica and in St. Lucia was that the Agricultural Instructor must be acquainted with the *patois* spoken by the people. Unless he were acquainted with *patois* his usefulness would be greatly reduced.

Mr. A. P. COWLEY (Antigua) mentioned that pen manure was used in the various islands in the experiments of the Imperial Department of Agriculture, and the results obtained probably varied according to its composition. He would like to know whether there was any standard by which to determine a complete pen manure.

The PRESIDENT pointed out that in the experiments carried on by the officers of the Department, the quality of pen manures used was considered as a 'good average,' and although the application of pen manures varied in quantity on different estates, yet one could arrive at a fairly accurate idea of what results might be expected from applications of pen manure by taking averages over several years.

Dr. WATTS drew attention to cotton-cake-meal, a manure that was generally of fairly uniform composition, and suggested that its use might be valuable in cacao cultivations.

The PRESIDENT was glad that Dr. Watts had referred to this matter. He would urge most strongly on those islands that were growing cotton to a large extent, that they should not export the seed but should use it either in the form of seed or meal as a manure. He desired therefore to emphasize what Dr. Watts had said about the manurial value of cotton seed and cotton-cake-meal.

Grafting Cacao.

BY JOSEPH JONES,

Curator, Botanic Station, Dominica.

In the *West Indian Bulletin*, Vol. VIII, pp. 131-8 a brief note on experiments in grafting cacao at the Dominica Botanic Station has been published. A further note is now submitted, in which the work done is briefly summarized and an indication of the position of these experiments at the present date given.

The first attempts at grafting cacao in Dominica were made in the Botanic Station nurseries in July 1905, when a good type of Criollo cacao seedlings and Alligator cacao seedlings were worked on stocks of *Theobroma bicolor*, with a view to finding if the latter would prove a suitable stock on which to grow the commercial varieties of cacao.. *Theobroma bicolor* did not prove suitable as a stock. Although the union of the cacao seedlings appeared complete, no growth followed, and the trial failed.

An attempt was then made to graft by approach young growing shoots of the Alligator cacao (*Theobroma pentagona*) on Forastero stocks. For this purpose a rough stage was placed near to a seedling Alligator cacao tree that had produced fruit. On this were placed the bamboo pots containing the seedling plants, and selected shoots of the Alligator cacao were grafted to the seedlings. The seedlings were supplied with water each day. In eight weeks the union was complete and the first batch of five plants was taken off and planted out on September 11, 1905. A second batch of eight plants was placed out on November 24, 1905. The cacao plants were set out in a field occupied by seedling orange trees, fifteen years old, planted at 20 feet apart, each cacao plant being placed in the middle of the square formed by four orange trees. The soil is dark in colour, easily worked, and may be described as fair cacao land. Probably the young cacao did not receive a fair chance when planted in soil already occupied by orange trees, but against this must be set the advantage they gained by shade from the older trees. These grafted cacao plants have grown very well, and now at two years and four months old they are bushy plants over 6 feet in height, and from 6 to 8 feet through the spread of branches. The number of half-developed cacao pods on the trees now (January 1908) averages four per tree. The manurial treatment has been 3 baskets of pen manure annually as a mulch to help the trees through the dry season.

It is expected that the trees when three years old should have yielded at least 1 lb. of cured cacao per tree. In Dominica, the Alligator cacao is a delicate tree and a shy bearer. Better results might probably be expected from selected Forastero strains of cacao grafted on Calabicillo stocks and planted in fields with only tannias and bananas for shade,

During 1906, the grafting of a hardy and prolific type of Forastero cacao on Calabicillo stocks was commenced. A plot containing sixteen plants of this variety was planted in August 1906. These, now nearly eighteen months old, are bushy plants from 4 feet to 5 feet in height and are very promising. In July 1907, another plot of thirty-five plants of this cacao was started. Tannias and Chinese bananas were planted to give the necessary shade.

The number of grafted cacao plants now growing in the Dominica Botanic Station is as follows:—

Theobroma pentagona	62	plants.
Selected Forastero	94	„
Total	156	„

At Picard Estate, Dominica, the property of Messrs. Rowntree & Company, an experiment plot of grafted Forastero cacao has been started. It contains 136 plants supplied by the Botanic Station. Other trials on a smaller scale are being made on various cacao estates. At the present time 200 plants have been ordered by planters from the Station for further experiments, and the plants will be delivered in the course of a few weeks. These trials should yield valuable information in the course of several years.

It will be understood that the appearance of grafted cacao plants in their early stages is quite different from the habit of seedling cacao. The seedlings grow with a single stem and do not usually branch, in Dominica, until 3 or 4 feet, and sometimes 5 feet, in height, depending on the soil, position, and amount of shade given. Grafted cacao plants branch a few inches above the point of union and form bushy specimens. This early production of several branches with a large leaf surface is probably one of the factors in causing grafted plants to fruit much earlier than seedling plants.*

Close on 500 grafted cacao plants have been obtained during eighteen months from an established cacao tree possessing desirable qualities. Had it been necessary, double this number could have been obtained from the tree by erecting additional staging on which to stand the bamboo pots containing the stocks. It will be noted that planters possessing cacao trees of a fruitful and disease-resisting type could increase them by grafting at a fairly rapid rate.

Some of the advantages obtainable by adopting the system of grafting cacao and forming future plantations with grafted instead of seedling plants would be as follows: Obtaining an even quality of produce requiring the same degree of curing; growing disease-resisting varieties; earlier fruiting, giving a quicker return on capital invested; increase of yield per acre by selecting prolific strains; and, possibly the dwarfing of the trees owing to grafting.

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* A tree planted on September 11, 1905, was photographed on March 25, 1908, and measured 9 feet in height and 9 feet through the spread of the branches at 3 feet from the ground. It was carrying sixty pods, and other grafted plants growing in the vicinity of the same age were carrying from thirty to forty pods each.—ED. *W.I B.*

Should grafting tend to dwarf cacao trees as it is known to do in the case of many varieties of mangos, this should be of advantage in islands like Dominica, as low-growing trees could be better protected from the wind. With dwarf trees it might be possible to sever all the pods with a knife held in the hands of the cacao gatherer, thus ensuring the crop being removed without injury to the tree, and doing away with the use of the cacao-hook, a necessity for gathering the crop of the upper branches of the present tall trees.

Even in the hands of a careful man the cacao hook does some harm to the trees, portions of the bark of the branch being often removed with the pods, either above or below the fruits, leaving wounds in which fungus spores may enter and set up diseased conditions. The prevalence of dead upper branches on cacao trees in islands where overhead shade is not given is attributed wholly to the effects of the sun and the wind, but the part played by the cacao hook in this matter, though it cannot be calculated, is undoubtedly considerable.

It will be more expensive to plant a field with grafted cacao than with seedling cacao, just as it is more costly to plant a field with budded orange plants than with seedling kinds, but the orange grower knows by experience that he is following right methods and that he will be repaid for the extra cost of budded plants. In like manner the value of grafted cacao plants may be demonstrated in the course of time, and cacao growers brought to adopt this system in further development of cacao cultivation.

EXPERIMENTS AT GRENADA.

BY R. D. ANSTEAD, B.A. (Cantab.),

Agricultural Superintendent, Grenada.

As mentioned in the *West Indian Bulletin*, Vol. VIII, pp. 130-1, the experiment plots of cacao at Grenada are of two kinds, distinguished for the sake of reference by the terms, 'experiment plots,' and 'experiment stations.'

The experiment plots are each about 1 acre in extent, and are chosen from land near the public roads, belonging to peasant proprietors.

One series of these plots completed its three-year course in 1904, and a fresh series, chosen on the same plan, but in different localities, has completed its second year. The results are briefly set forth in the following table :—

Experiment Plots.

No.	Manurial treatment.	Yield in pounds of wet cacao. 1905-6. Per plot.	Per tree.	1906-7. Per plot.	Per tree.	Difference on no manure in 1906-7. Per plot.	Per tree.
1. B	No manure.	265	2·8	226	2·4	...	...
2. A	,,	...	...	153	3·3	...	...
3. A	,,	...	...	352	3·4	...	..
4. A	,,	295	3·0	657	6·7	...	...
5. A	,,	323	3·1	510	4·9	...	...
2. B	Phosphate as basic slag.	...	...	168	2·2	+15	+1·1
3. B		..	.	696	14·5	+344	+11·1
5. B		188	3·9	368	7·6	−142	+2·7
1. A	Phosphate and potash.	388	5·1	286	3·8	+60	+1·4
5. C		159	1·8	595	6·7	+85	+1·8
2. C	Phosphate and sulphate of ammonia.	..	...	148	1·9	−5	−1·4
4. D		117	1·4	411	5·0	246	−1·7
4. B	Phosphate and nitrate of soda.	275	2·8	516	5·3	−141	−1·4
2. D	Sheep manure.	...	...	103	1·1	−50	−2·2
3. D	,,	...	...	565	4·3	+213	+0·9
5. D	,,	210	1·6	326	2·5	−184	−2·4
4. C	Ohlendorff's manure.	390	4·2	648	7·1	−9	−0·4
1. C	Mulching.	253	2·6	250	2·6	+24	+0·2

Considerable interest has been shown in these experiment plots by the peasants in their districts, and the operations carried out upon them are, to a large extent, followed. The plots were originally chosen in poor areas and where trees have been considerably neglected. The Agricultural Instructor uses the plots to meet the peasants and to show them how agricultural operations such as forking, drainage, and pruning should be carried out, and how manures should be applied. A good crop serves as an excellent object-lesson to all cultivators of cacao and indicates how the most satisfactory results are to be obtained.

With regard to the actual results of the experiments, figures are kept as accurately as possible and published from year to year in the Annual Report of the Botanic Station. As a means of obtaining accurate numerical results, the second class of experiments, the 'experiment stations' afford better opportunities than the experiment plots, since they are on a bigger scale and are run more on estate lines.

Three of these stations have completed their first year's course, and the results are briefly set forth in the following table:—

EXPERIMENT STATIONS.

No.	Manure.	Yield in pounds of wet cacao.		Difference on no manure.	
		Total.	Per tree.	Total.	Per tree.
Tuileries III.	No manure	1,253	6·3	—	—
Waltham III.	" "	1,759	8·8	—	—
Tuileries IV.	Lime	1,581	7·9	+ 328	+ 1·6
Waltham I.	"	1,643	8·2	- 116	- 0·6
Tuileries I.	Sulphate of ammonia	1,367	6·8	+ 114	+ 0·5
Waltham IV.	" " "	2,157	10·8	+ 398	+ 2·0
Tuileries II.	Sulphate of potash	1,588	7·9	+ 335	+ 1·6
Waltham V.	" " "	1,931	9·6	+ 172	+ 0·9
Tuileries V.	Pen manure... ...	2,423	12·1	+ 1,170	+ 5·0
Waltham II.	Basic slag	1,517	7·6	- 242	- 1·2

These experiment stations are established on large estates and consist of not less than 5 acres or 1,000 trees. These stations, of which there are at present six, have become very popular, and next year it is hoped to start several others.

The result of their establishment has been to make the larger proprietors take a lively interest in experiments carried out on their own estates, experiments designed to answer questions and solve problems connected with their own soils and conditions.

It is not proposed to discuss these results at length, but merely to dwell on a few salient points.

The experiments show that nitrogenous manures are of the greatest value for cacao in Grenada and that the use of phosphate without nitrogen is not beneficial. The use of potash without nitrogen, on the other hand, appears to result in increase of yield.

The cacao soils of Grenada consist of stiff clays strikingly deficient in lime, so that the beneficial results obtained by the application of lime are not surprising.

EXPERIMENTS AT ST. LUCIA.

BY J. C. MOORE,

Agricultural Superintendent, St. Lucia.

Of the experiment work carried out at St. Lucia, that in connexion with the improvement of cacao cultivation has been followed by most beneficial results. This is apparent from the growing popularity of up-to-date methods of culture and manuring, the generally improved condition of the trees, and the increased crops on many plantations where treatment has been adopted similar to that which has been found most successful on the experiment plots. This work has been carried out on cacao estates in different parts of the island over a period of five years, entirely at the expense of the Imperial Department of Agriculture. These plots were each an acre in extent, were situated on the main roads, and were generally chosen on neglected properties. The objects in view were to demonstrate, if possible, that neglected and unhealthy trees could be restored to health and increased bearing by careful methods of cultivation. It was hoped that these improved conditions would be closely observed by the peasants and others, and would persuade them to adopt similar measures on their own properties. The Agriculture Instructor gave particular attention to this improvement of cacao cultivation, and the periodical reports of this officer show that much useful work has been accomplished.

As reported at the last Conference, it has been found that intensive culture in cacao is very profitable, for it improves the vigour and disease-resisting powers of the trees. It has also been shown by these plots that the use of basic slag and sulphate of ammonia is followed by profitable increases in crops, but that the best results may be expected when pen manure or other suitable organic manure is used in addition to artificials

In 1906, all these cacao plots were relinquished, for it was thought that they had served their purpose, and a new series was undertaken on similar lines as those established in Dominica and Grenada. Under the new arrangement, all working expenses and cost of manures are borne by the plot proprietor, scientific advice being given as to treatment by the officers of the Department. Each plot is divided in five equal sections (generally ½-acre sections) and is treated as follows:—

Section.	Manurial treatment.	Cultural treatment.
A.	Control, no manure.	Annual forking.
B.	Stable manure, 5 tons.	Annual forking.
C.	Mulching with grass or leaves, 10 tons.	No forking.
D.	Basic slag, 4 cwt., sulphate of ammonia, 1 cwt.	Annual forking.
E.	Sulphate of potash, ½ cwt., sulphate of ammonia, 3 cwt., lime, 10 cwt.	Annual forking.

It is too early yet to say much of the results that have been obtained, but accurate returns are being kept and will be reported later. In section C, it has been found that a mulch of 10 tons per acre was hardly sufficient to cover the ground thoroughly, and planters who contemplate giving this system a trial are recommended to increase the quantity. The cost of cutting and applying grass and bush from adjoining vacant lands is about 2*s*. 6*d*. to 3*s*. per ton.

Plots of cacao have been established at the Experiment Station attached to the Agricultural School. The general condition in 1906-7 of one of these plots was much improved by two applications of grass in the form of a mulch. At each mulch, about 190 bundles of rough grass, of approximately 100 ℔. weight each, were used, and it was calculated that the cost of cutting, heading, and spreading this grass worked out at 2½*d*. per bundle, or about 4*s*. 6*d*. per ton.

Since mulching has been adopted, there has been a very noticeable improvement in the vigour of the trees and they are less affected in the dry season. The soil also appears to have benefited by this treatment, and fungus diseases have been less prevalent.

CACAO EXPERIMENTS IN BRITISH GUIANA.

BY PROFESSOR J. B. HARRISON, C.M.G., M.A., F.I.C., F.C.S., F.G.S.,

Director of Science and Agriculture, British Guiana.

When the Government acquired Onderneeming many years ago some acres of it were occupied by a recently started cultivation of cacao. This was gradually extended, and about 16 acres are now occupied by this crop. Not much attention seems to have been given to the cacao plants, and when in 1899 I was placed in advisory control of the Onderneeming School Farm, the cacao plantation was in very bad order and its yields were very low. When first started, Oronoque trees (*Erythrina glauca*) were planted closely together through the cultivation to supply shade. They had been allowed to grow almost without restraint, and the result was a more or less forest-like growth, in the gloom of which the cacao trees struggled for existence. But although drawn up and more or less dwarfed in their general development, the cacao trees were singularly free from disease.

I commenced operations on the cacao field in the year 1900 by cautiously and gradually thinning out the Oronoque trees, so that in the course of twelve to eighteen months I had reduced their number by three-fourths, the greater part of those left standing being in positions where they form a wind-break or shelter-belt to the fields, whilst those remaining sparsely scattered through the cultivation had been severely pruned. This resulted in letting in light and air to the cacao, but in so gradual a manner that the trees were not injured by unaccustomed exposure. During the four years preceding the reduction of the shade the mean annual yield was 1,064 lb. of cured cacao, whilst during the succeeding six years the annual crop has been at the mean rate of 1,870 lb.

After the cacao trees had become accustomed to the altered conditions under which they were growing, a series of trials with artificial manure was commenced.

I realized that experiments of this sort with fruit-bearing trees, such as cacao, offered a far more difficult problem for solving than do experiments with sugar-cane. The individuality of the trees appeared to me to be a disturbing factor and one that would be exceedingly difficult to overcome.

As a preliminary step we determined the yields of cacao per tree in the fields over the beds of cacao, each of which is approximately ⅓ acre in area. From among these we selected beds having a mean of about 100 trees growing on each, the numbers on them varying from a minimum of eighty-eight to a maximum of 102, and upon which the yields of cacao had been approximately uniform. The beds are longitudinal, extending across the field from east to west. By this means we selected as apparently of equal productive power sixteen plots for the experiments.

Analyses of the soils of the plots were made, which showed that they were fairly heavy clay soils, although lighter than

the usual run of the cultivated soils on the coast-lands of Demerara.

The following were the determinations of the soil constituents usually considered as of importance :—

	Per cent. of air-dried soil.		
	No. 1.	No. 2.	No. 3.
Nitrogen	·131	·174	·122
Potash soluble in boiling hydrochloric acid ..	·482	·589	·502
Potash soluble in 1 per cent. citric acid	·0097	·0043	·0052
Lime soluble in boiling hydrochloric acid ..	·233	·245	·248
Lime soluble in 1 per cent. citric acid	·0342	·0472	·0390
Phosphoric anhydride soluble in boiling hydrochloric acid	·091	·086	·065
Phosphoric anhydride soluble in 1 per cent. citric acid	·0038	·0047	·0025

The analytical figures led to the expectation that applications of potash salts and of phosphates were probably necessary for the successful growth of cacao on these soils. But the relatively high proportion of potash present in a state soluble in hydrochloric acid indicated that tillage operations would probably render available sufficient of the potash for the need of the plants.

During the course of the experiments very full and complete records were kept by Mr. P. deWeever, Schoolmaster at Onderneeming, who devoted much time and great care to carrying out the details of the experiments.

The manures tried were :—

1. Sulphate of ammonia.
2. Sulphate of potash and superphosphate of lime.
3. Sulphate of potash and sulphate of ammonia.
4. Superphosphate of lime and sulphate of ammonia.
5. Sulphate of potash, superphosphate of lime, and sulphate of ammonia.

It was pointed out by me in 1904, that the returns of cacao from the trees for one season only would not represent the actual action of the manures. The crops were therefore determined during four years, from March 1903 to April 1907.

The average number of pods, their weights, and the average weight of cacao-pulp yielded per tree per annum during this period are shown by the following :—

Manurial Treatment.	Per tree per annum.		
	Number of pods.	Pods, weight in pounds.	Weight in pounds of pulp.
No manure	9·0	7·4	1·47
Sulphate of potash and superphosphate of lime ...	9·2	7·7	1·58
Sulphate of ammonia ..	8·6	7·1	1·50
Sulphate of potash and sulphate of ammonia ...	9·9	7·9	1·61
Superphosphate of lime and sulphate of ammonia	9·4	8·4	1·83
Sulphate of potash, superphosphate of lime, and sulphate of ammonia ...	9·9	8·0	1·70

For the purposes of these experiments Mr. deWeever during the year 1902-3 counted the pods produced on a considerable number of beds on the Onderneeming cacao fields, determined the weight of pulp yielded by them as delivered at the sweating house, and the weight of cured cacao obtained.

His results were :—

Number of pods	15,518
Weight of pods	12,553 lb.
Weight of pulp	2,555 „
Weight of cured cacao	1,016 „

The cacao trees at Onderneeming on the experimental beds are planted approximately at 300 trees to the acre. The yields of cured cacao per acre per crop, calculated by the use of the above data, work out as follows :—

Manurial Treatment.	Yield of cured cacao per acre.
No manure	176 lb.
Sulphate of potash and superphosphate of lime	187 „
Sulphate of ammonia	178 „
Sulphate of potash and sulphate of ammonia	191 „
Superphosphate of lime and sulphate of ammonia	218 „
Superphosphate of lime, sulphate of potash, and sulphate of ammonia ...	202 „

The above indicates that on the soils on which the trials were conducted the manure which exerts a favourable influence in the yields of cacao, is a mixture of superphosphate of lime and sulphate of ammonia. Sulphate of potash is not indicated as being required, and, in fact, little good resulted from its application. Nor has the use of sulphate of ammonia by itself proved satisfactory. In the mixed manuring of sulphate of ammonia and superphosphate of lime the cost of the sulphate of ammonia was $7·50, that of the superphosphate of lime $2·50—a total of $10 per acre. The increased yield of cacao presumably due to the action of the manures during the four years, was 168 lb. worth locally at 12 c. per lb., $20·16. Allowing 6 per cent. per annum as interest on the capital expended in the manures, we get $7·76 as profit from the manuring.

The following, in my opinion, illustrates some of the uncertainty which attaches to manurial experiments with cacao. The yields of cured cacao per tree per crop during the period 1903-7 were as follows:—

Not manured experimental beds ...	...	·58 lb.
„ „ rest of fields ...	..	·72 „
Manured experimental beds ...	...	·66 „

The cause of the higher yields per tree over the parts of the field not under experiment, is that on them the bearing trees are planted somewhat farther apart from one another than they are on the carefully selected beds used for experiments with manure.

In the preliminary determinations of their yields during the selection of the beds, it was found that the yields on three beds selected for unmanured control plots were 1·04, 1·38, and 1·20 lb. of pulp per tree per crop. A fourth one, with trees

planted at the same distance apart as were those on the three beds, yielded 2·40 lb. of pulp per acre. If this bed had been used as an uncontrolled manured plot for manurial experiments and any one of the other three as an unmanured reference plot, we should have obtained some striking results relating to the actions of manures on cacao. As it is, reference to the figures given above shows that the results obtained were, as they are in all well-arranged agricultural field trials, unmarked by phenomenal yields attributable by the experimenter to some special form of cultivation or of manure.

My experience with cacao indicates that to obtain reliable results the plots used must be relatively large ones, containing at least 100 trees on each, and that each trial should be repeated on at least three plots and preferably on four or five. Then the mean results obtained over a series of crops although probably not in any way striking, may be accepted as fairly reliable.

DISCUSSION.

Hon. W. GRAHAME LANG (Grenada): We in Grenada agree with Professor Harrison's remarks as regards shade. We find that wherever cacao is heavily shaded, a good deal of disease exists: but as soon as the shade is removed the cacao trees improve in condition.

The PRESIDENT said that the question of shade was a matter which had to be treated according to local conditions. No hard and fast rule or law could be laid down with regard to any particular district until actual trials had been made. Side shade and shelter were necessary: but overhanging shade was a matter in which one must be guided by local conditions.

Professor HARRISON, replying to the Hon. G. W. Hazell, said that the usual shade tree in British Guiana was Bois Immortel, but they were now establishing wind-breaks of rubber trees.

Dr. WATTS (Leeward Islands) said it occurred to him that the question of soil moisture and drainage was somewhat related to that of shade, and it was questionable whether a great deal of the beneficial effect attributed to shade was not attributable to drainage through the roots of the trees. From what he had seen in one or two places where he had taken careful note of trees growing in damp situations, there was a drainage effect which was beneficial both in the case of lime and cacao trees. In Dominica, and Grenada cacao flourished much better without shade, whereas in Trinidad they had a country which was a great advocate of shade, and he was not certain whether it was not rather a question of drainage.

The PRESIDENT remarked that the point raised by Dr. Watts was a very important one and deserved investigation.

THE CHARACTERS OF CRIOLLO CACAO.

BY J. H. HART, F.L.S.,

Superintendent, Royal Botanic Gardens, Trinidad.

Criollo cacao, as represented by the specimens exhibited, may be divided into three sections: (1) Trinidad Criollo, (2) Venezuelan Criollo, and (3) Nicaraguan Criollo.

Trinidad Criollo is supposed to be indigenous to Trinidad. The specimens exhibited are the produce of trees grown from pods selected by G. Kernahan, Esq, taken from original forest in the district of Manzanilla, Trinidad. Some of the pods were yellow, and some red. It has been found that seeds from yellow pods are able to produce trees bearing red pods, while those from the red pods often produce trees bearing yellow pods.

The generally light colour of the beans and their form are characteristic of the variety, while the bottle-necked appearance of the pods is a leading feature by which they may be recognized. This type of Criollo cacao is not quite as vigorous as are the Forastero and Calabacillo types, and though a fairly good bearer, does not yield as well as those kinds.

Venezuelan Criollo differs in form from that of Trinidad, as the stalk end is blunt and rounded instead of being bottle-necked. The beans are larger in size than those of Trinidad Criollo, and differ somewhat in form; but like the Trinidad kind, the beans when cut show a white or nearly colourless interior.

Specimens of this kind of Criollo cacao grown in Trinidad have been produced from seed obtained from one of the best Venezuelan estates. The produce shows considerable variation both in outside colour and form of the pods, as well as in the colour of the beans. They are not prolific bearers, but the quality of the produce is of the highest class, and estates possessing this strain can obtain high prices.

This kind is also known under various other names such as *Caracas*, *Borborata*, etc., etc.

The Nicaraguan Criollo differs somewhat from the Venezuelan in form of pods. The size of the bean is also much larger. The colour of the bean is white and not so often shaded with colour as the Venezuelan, and Trinidad Criollos.

The pods are rather more pointed in form than the Venezuelan, but much resemble them in other respects.

The beans produced by this kind are probably the largest of any known variety of *Theobroma cacao*, and compare very closely with those produced by *Theobroma pentagona*, a species with which it may have become hybridized in Nicaragua. The bean of the Nicaraguan Criollo, like that of *Theobroma pentagona*, is, for its size, light in weight. It possesses a flavour of very high standard and takes much less time to cure than

ordinary Trinidad cacao. Propagated by grafting and kept pure, this cacao promises to become a valuable acquisition to West Indian plantations.

GENERAL REMARKS.

Grown as seedlings, these three varieties are not heavy bearers, and as crop producers cannot be compared to the stronger growing strains of Forastero and some other varieties. All three kinds possess valuable characters, and it is highly probable that when grafted on the stronger stocks, their yield would be materially increased, and they would become a valuable asset to the West Indian cacao planter.

THE IMPROVEMENT OF CACAO PLANTING IN THE WEST INDIES.

BY J. H. HART, F.L.S.,

Superintendent, Royal Botanic Gardens, Trinidad.

Cacao estates in Trinidad are largely planted on what is known as the contract system. Under this system the proprietor gives out certain areas to a contractor, and after the land has been cleared at the expense of the owner, the contractor enters into possession for usually about five years. During this time the contractor drains the land and grows certain crops for his own benefit, and at the same time plants cacao as laid down by contract. When the lands are taken over by the owner from the contractor, 1*s.* to 1*s.* 3*d.* is paid for each full bearing tree, half that price for each half tree, and a quarter for each quarter tree.

The general adoption of this system appears to depend upon the fact, that under it, less immediate expenditure of capital is incurred, and the planter when he has paid for the trees at the end of the term, should immediately obtain some return for his money, for many of the trees should be commencing to bear. Briefly, the proprietor gives the land for five years, for the cultivation of food products, with some few restrictions, in return for the labour expended in planting and rearing the cacao trees with addition of a bonus per tree at the end of the term.

In Tobago, the contract system is not generally adopted, and some estates are formed by the owners. There is but little difference to be noticed between an estate planted under contract, and one planted by an owner. The actual method of planting under both systems is identical; the same class of tree is planted, the same shade is used, and the same technic is adopted in both cases.

The methods pursued in other places vary somewhat from those described, but are in principle fairly identical.

There is no reasonable doubt that although the contract system may have its advantages as affording a cheap means of establishing a plantation, it is not one which provides for the scientific treatment of the cacao tree, as it is based entirely

upon growth from seed. The cacao tree grown from seed varies in vigour, and productiveness, and in size, colour, and flavour of its produce. The seed of red pods may produce trees bearing yellow ones, and those from yellow may produce trees possessing red ones. In the seed itself there is great variation in size, colour, flavour, and number of seeds to a pod.

These variations, left to themselves, are (following the accepted doctrines of our best botanists) sure to tend toward deterioration; but properly guided they afford the means of not only maintaining a standard, but of improving that standard in any desired direction.

At the present time, Trinidad cacao is an interminable mixture of various types near to, and far from, the original strains. The better types prevail where a preponderance of the better kinds were first planted, and the poorer types in those districts where numbers of inferior strains are present.

It would appear that there is little cacao true to the original types of old authors, and although the various strains can be recognized, it is much more easy to notice the variation that has occurred, even during the last two decades. Trinidad Criollo can still be recognized generally, but the bottle neck of that variety is now to be seen plainly marked in varieties where the Forastero strain predominates. The Venezuelan Criollo may be seen apparently true in form and colour with the accepted type, but an examination shows that the plants may have coloured, instead of white, beans.

I suggested in 1897, that it was urgently necessary when raising from seed, to be extremely careful in selecting from the very best trees, but I am now quite convinced that this method, while being better than no selection at all, is quite insufficient to secure the highest class of produce, and that vegetative production by budding or grafting must be adopted, if cacao is to be improved along scientific lines. In 1897, it was not certain that budding or grafting was practicable with cacao, but it has since been proved that they may easily be performed. Recently I prepared an article on cacao improvement that was published in the *Trinidad Bulletin*, Vol. VII, p. 183. In this was described in detail the method necessary for the improvement of plantations.

The principal points are (1) the entire abandonment of propagation from seed except for the purpose of raising new and improved varieties, (2) improvement by the aid of hybridization or seminal variation, (3) the selection of standard varieties from present fields showing desired characters in order to propagate from them by grafting or budding, and (4) the characters to be used in making the selection should be high vitality, good bearing qualities, good habit and form, and a high quality of produce.

At the Conference held at Trinidad in 1905, I presented a paper on the special qualities of plants. In it I presented arguments to show that special qualities are inherent in each and every individual plant, which remain constant through its life and may be propagated indefinitely for centuries; and

I am more than ever confident that if these views are brought into practice in the working economy of cacao estates, a very great improvement in the quantity and quality of the produce obtained would rapidly follow. One tree in the Botanical Department, Trinidad, produced in 1907, 15 ℔. 9 oz. of marketable cacao, and it would appear desirable that such a tree should be among the selected varieties to be reproduced by vegetative reproduction.

In cacao plantations there are trees of a high class, and also many of an inferior type. The latter, being as a rule of greater vegetative vigour, tend to dominate, and gradually may push out the better strains. In the following generations, when again reproduced by seed, deterioration necessarily occurs and a large number of interbred varieties is produced.

It is satisfactory, however, to note that not a few planters are alive to this danger of deterioration in quality, and have imported of the best strains from the mainland of South America. Even these show considerable variation. These importations, nevertheless, are of superior quality, and they must have an effect, though a limited one, in improving the standard quality of Trinidad cacao. The improvement can only be a transient one, as the inferior kinds, being the more vigorous and in the majority, will again, in time, dominate the better qualities. If, however, selections are made of the most distinct forms, and these are propagated solely by vegetative reproduction, the improvement would most assuredly be a permanent one, and when once standard and selected kinds are propagated by this method alone, and not by seed, deterioration would cease, and no change in the quality of produce could occur, except that induced by unfavourable weather, accidents during curing, or by unfavourable situations.

Trinidad cacao has obtained a name for certain good qualities, but manufacturers cannot use Trinidad cacao alone. They require other and often higher-priced qualities to mix with it, to obtain the necessary blends. The average grower may be content with his returns, but why should not the West Indies with her excellent facilities for growing cacao be possessed of and grow all the various kinds needed by the manufacturer to make the required blends, for the production of high-class chocolate and cocoa? Or why should not the West Indies possess sufficient of each kind to be able to start successfully the local manufacture of various cacao products?

It cannot be done to-day, because several of the special qualities necessary for making the flavours now recognized, and demanded, are absent from West Indian cultivation. Therefore it is important to encourage the introduction of plants of all the foreign cacaos which are necessary for the preparation of the manufacturers' blends. They should be kept pure by reproduction solely by budding and grafting.

The West Indies would then be able to put into the hands of the manufacturer all that he needs in the way of qualities.

It may be said that prices of Trinidad cacao are at present satisfactory. But will they always be so? Every endeavour

should be made to take advantage of every improvement to raise the quality of cacao, as in years of bad prices it is well known that certain brands sell at higher rates than others, because the manufacturers require them, and that in general a pure brand or well-known mark, is accepted at higher prices than ordinary mixed strains. There is nothing to be said against a grower who wishes and prefers to grow a low-grade cacao, but it is fairly clear that his returns will not equal those obtained by the growers of high-class produce, and even these will fetch more if kept pure by vegetative reproduction, as they can be better relied on for strength and evenness of quality.

The question of the production of high-class cacao of the various market qualities, appears to be a very desirable one and should be the aim of cultivators who wish to attain to a high standard.

DISCUSSION.

The President: I am glad to take advantage of this opportunity of expressing the general feeling in the West Indies in regard to Mr. Hart's long and useful career in connexion with agriculture. Mr. Hart spent the earlier years in Jamaica where he was connected with my Department there. He has since been in Trinidad, and there can be no doubt whatever as regards the earnestness and thoroughness with which he has carried on his work. I am very glad of this opportunity of putting that on record, and also of thanking him for this very useful and I think very suggestive paper which he has presented before the Conference to-day.

FUNGUS DISEASES OF CACAO AND SANITATION OF CACAO ORCHARDS.

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Fungus diseases of cacao have from time to time occasioned considerable losses, and during the last ten years have been under careful investigation. Most of the principal diseases have been dealt with at previous Conferences, but as they have been particularly prevalent in certain of the West Indian colonies during the past two years, it is proposed to present to this Conference a complete review of these diseases, together with the additional information that has been obtained respecting the treatment of them and of the new diseases that have come under observation. Particular attention will also be drawn to the sanitation of cacao orchards, in the hope that assistance may be rendered to cultivators towards reducing and preventing those losses that are frequently overlooked and sometimes, it is feared, totally disregarded.

In old records of the West Indies, reference was made to 'blights' that affected the cacao in different localities, but it was not until 1898 that attention was specially drawn to specific fungus diseases. In that year, some diseased pods were brought under observation in Trinidad and were investigated by the Botanic Department of that colony and by Kew. A year or so later, careful investigations were commenced by Mr. Howard, (then Mycologist attached to the staff of the Imperial Department of Agriculture) of fungus diseases of cacao of Grenada. Since then observations have been continued in Dominica, St. Lucia, and St. Vincent, and the parasitic fungi on the cacao tree have been under thorough investigation. Considerable information in respect to life-histories of the fungi and to remedial treatments of the diseases has been acquired, and it has been satisfactorily demonstrated during the past few years that practically all the different diseases are amenable to treatment. Reliable data in respect to the success of various remedial measures have been forthcoming. It has been shown by the experiment plots, established by the Imperial Department of Agriculture in various districts in the different West India Islands, where diseases had been allowed to develop almost to a maximum, that such diseases may rapidly be reduced to a minimum by careful treatment. The increase in crops thereby obtained, moreover, allowed of a sufficiently good margin of profit over the increased expenditure incurred in cultural operations to commend such treatment for the consideration of all cacao cultivators.

The most important of the cacao districts of the West Indies have been surveyed for the purpose of obtaining information in respect to the occurrence and damage incurred by the different fungus diseases. Observations have recently

been made in Dominica, St. Lucia, and St. Vincent, while cacao at the Botanic Station, Grenada, and in some districts of Trinidad has also been inspected. During the last year, Mr. O. W. Barrett has been engaged in studies in Trinidad and has issued several reports.

It is proposed to group the diseases of cacao under sub-heads: (1) Root disease, (2) Stem diseases, and (3) Pod diseases, while at the end of the article notes will be given on general sanitary observations for cacao plantations.

ROOT DISEASE.

Attention to a root disease of cacao in the West Indies was first called by Barber in his report on the failure of the Dominica cacao crop of 1892-3. It was recorded to affect also mangos, oranges, coffee, and bread-fruit. In 1901, Howard investigated a root disease in certain districts of Grenada, and recorded that a similar disease affected nutmegs and many other cultivated trees. The opinion was also expressed that Dominica and Grenada diseases might be identical. A similar disease was also known to occur in cacao and coffee cultivation in Jamaica.

Later in the same year, specimens of cacao trees affected with root disease from Dominica were examined by Howard in the mycological laboratory of this Department, and it was found that the roots had been affected by a fungus that closely resembled that observed in the Grenada cacao root disease.

A somewhat similar root disease of cacao is reported to occur in the Cameroons and coffee is affected in Gaudeloupe, while other root diseases have been reported from cacao and other plants in Ceylon, Samoa, and Java.

Recently investigations have been made into the occurrence of root disease of cacao in the various cacao-producing districts of these islands, and it has been found that this disease occurs fairly commonly in many parts of Grenada, Dominica, and St. Lucia. Remedial measures have been given careful trial, and it has been found that this disease is quite amenable to treatment if taken during its early stages. Examination has been commenced of the fungus that causes this disease, but in spite of the frequent occurrence of the disease, no fructifications have yet been found in the field nor have they been produced in the laboratory.

Clamp connexions characteristic of the Basidiomycetes have sometimes been observed in the fungal hyphae but opinion as to identification of the fungus must be deferred until further investigations have been completed and until fructifications have been obtained.

The root disease of coffee and pois-doux in Guadeloupe has been described by Delacroix, who believes that the fungus observed may be a species of *Dematophora* or of *Rosellinia*. The fungus in Samoa and in Ceylon has been attributed to *Hymenochaete*, and that in Java to *Sporotrichum*.

It is obvious, therefore, that root diseases affect cacao in many widely separated countries, and it is possible that a careful description of the disease known in Grenada,

Dominica, and St. Lucia may be of interest, while the remedial measures that have been found to be successful cannot fail to attract attention. This disease is sometimes alluded to in these islands as 'canker of the root.'

Symptoms.—Trees affected with root disease present a sickly appearance. The leaves become small and assume a yellowish hue, while the branches begin to wither from the tips—the leaves wilting. These branches eventually die off, and subsequently the whole tree may be killed. Trees are rarely killed off singly but usually in patches. These patches of dead trees, unless something is done, increase in size, and it has been observed in Dominica when the disease has been neglected that areas of nearly an acre in extent have been destroyed.

It has frequently been noticed—though this is not always the case—that these patches, when they are quite small, are circumscribed by the spread of roots from trees that have been used for shade. Pois-doux, bread-fruit, bread nut, mango, pomme rose, and avocado pear, which are dead or dying, have been commonly observed in the centre of the diseased area, and it has been suggested that the fungus attacks the dead or dying roots of these trees and then affects the young roots of the cacao. It has undoubtedly been established that the fungus under consideration may spread from affected roots of pois-doux or bread-fruit, and it has been observed to spread for a considerable distance along a pois-doux wind-break from tree to tree.

In Dominica, it has been found that cacao has become affected where none of the above mentioned trees were present, and it was difficult, owing to the length of time that elapsed since the disease first made its appearance and when investigations were made, to establish clearly at what spot the disease commenced. On this estate, the soil of which appeared to be of uniform quality, a patch of fifteen to twenty trees were killed out, and then at a distance of say about 100 yards another patch were destroyed. The intervening trees were quite healthy and their roots did not in any manner appear to be affected. In this island it has also been found that root disease is fairly prevalent in cacao fields recently planted in cleared forest land, but it is suspected that more than one species of fungi are interested in this trouble, and that the disease may have originated from the fungi found on the decaying logs lying about the fields.

If the roots of a diseased cacao tree are laid bare and carefully examined, it will be found that many of them are black and decayed. Careful observation will reveal the white strands of a fungus mycelium attached to these roots, and passing into the bark and into the tissues of the root. If, however, the bark of diseased roots is peeled off, a white web of fungus mycelium—usually arranged in somewhat star-like masses—will be found between the bark and the wood. This is a typical sign of the disease and is always to be observed in the larger diseased roots.

The mycelium is at first white, then grey, and finally assumes a light-brown colour. From this mycelium, hyphae may be followed into the deeper woody tissues of the roots, and almost

a white rot takes place. During the growth of the mycelium the woody tissues of the root become softer and lighter, while frequently dark-coloured streaks caused by the accumulation of some gummaceous substance, may be seen distributed throughout the root. Eventually, the water in the soil aids a wet rot, and the diseased roots, except the bark, become quite soft and rotten.

In the younger roots, the typical mycelial threads between the bark and the wood is not apparent, but there is usually a brown discoloration of the inner bark tissues due to gummy substances being formed through the attack of the fungal threads.

When the fungus has invaded all the principal roots or has spread upwards and encircled the lower portion of the stem, the tree dies. The disease, however, is not a rapid one, and when taken in the early stages has been found to be quite amenable to treatment.

Spread.—The spread of the disease is by underground mycelium. It frequently commences, as above stated, from pois-doux, bread-fruit or other trees, and it is seldom that it can be detected in its very initial stages, for when it is noticed several cacao trees—usually in a circle -have been infected.

Remedial Measures.—Whenever pois-doux, bread-fruit, bread nut, mango, pomme rose, or avocado pear trees are noticed in a cacao plantation to be dying, they should immediaately be taken out and burned. Particular care should be taken thoroughly to extract as many as possible of their roots and destroy them. Trenches should also be dug, to cut off the roots of the cacao tree from those of the trees in the infected spots. It is frequently advised that bread-fruit, bread nut, and avocado pear trees should not be planted amongst cacao in new plantations, and when any such trees have to be removed from old plantations care should be taken to extract their roots. The pois-doux is not very often attacked, and, therefore, may be used for wind-belts; but these trees should be carefully watched, for it has been observed that this disease has often commenced among cacao from dead pois-doux.

When an area of cacao is affected, it should be isolated from the remainder of the plantation by digging a trench, about 2 feet deep and 18 inches wide, around the diseased trees. This encircling trench should be connected with the general drainage system to prevent the lodgment of water, and care should be taken to include all the unhealthy trees in the circumscribed area, and to throw the earth from the trench into this portion that has been cut off. The surrounding healthy trees should be kept under observation for some time in order to ascertain whether isolation has been complete. If it has not, a further trench encircling a larger area must be dug.

All the trees in the affected and isolated area must now be carefully examined. The most badly diseased ones should be taken out, their roots extracted, and the whole burned. Others less badly affected should have the soil removed from

their principal roots, and the roots laid bare. The diseased roots should be cut off, and the diseased parts removed and burned. A good application of lime—say 5 lb.—should then be given in the holes that have been made around the trees, while laying bare the roots, and turning back the soil. If a large number of roots have ad to be cut off, a good heavy pruning should be given to the tree, in order that it may not suffer from excessive transpiration while possessing a reduced root area.

The whole of the isolated area, after the trees have been separately examined and treated should then be properly forked, and a good application of quick lime—at the rate of about 10 lb. per tree, should be broadcasted. After a time, applications of pen manure and mulchings should be given, and in the following year another general application of lime—at the rate of about 3 to 4 lb. per tree should be made. After the first general thorough forking, it is advisable that further forking should not be given for some years unless the trees are falling back, the land being kept in good tilth by heavy mulchings of grass and leaves. Forking always causes wounds to the roots, and if fungus is present in the soil, it is a means of spreading the disease.

Planters who have followed these remedial measures in Dominica and St. Lucia have saved considerable numbers of trees, and it has clearly been demonstrated that this disease, if it is taken sufficiently early may be successfully treated.

STEM DISEASES.

CANKER.

This disease of the bark of stem and branches of the cacao tree first came into prominence in Ceylon, where it was investigated by Willis, and later more fully by Carruthers about 1897. The latter investigator showed that the disease was caused by a parasitic fungus, which he referred to *Nectria ditissima*, Tul. Attention was called to a disease in cacao in Trinidad by Hart, who in 1898 sent specimens of a fungus on pods of cacao to Kew for identification. This fungus was referred to *Nectria Bainii*, Massee, and it was advised that care should be taken to avert any attempt on the part of the fungus to attack the trunk of the cacao tree on account of the distinctive canker disease in Ceylon being attributed to a species of *Nectria.* Subsequently another species of *Nectria* was found by Hart destroying the bark of cacao trees in Trinidad and was forwarded to Kew. In 1901, Howard investigated a 'canker' disease of cacao in Grenada, and the fungus found was referred by Massee to *Nectria theobromae*, n. sp., and stated to be identical with a fungus sent some time previously by Hart from Trinidad. The technical description of this fungus has not yet been published, but it seems to differ from *Nectria Bainii* in its perithecia. Howard also obtained another fungus in Grenada from cankered trees, and this was named by Massee, *Calonectria flavida*, n.sp. This fungus was subsequently noticed in Dominica and also was noted in Trinidad by Hart. A species of *Fusarium* is also associated, but is supposed to be saprophytic.

Inoculation experiments conducted by Howard in Grenada by introducing ripe spores into wounds in cacao trees showed that both *Nectria theobromae* and *Calonectria flavida* were parasitic in habit, for in each case distinct infection was produced. Experiments have yet to be conducted with *Nectria Bainii*, and, as this fungus has only been recorded from pods it has yet to be shown that it may in any way be associated with canker in the stem or branches in Trinidad.

It has been found that *Nectria theobromae* and *Calonectria flavida* may occur together in the diseased area, while at other times they may occur alone. In Dominica, it was supposed at first that the last mentioned was alone responsible for the canker in cacao, but recently *Nectria theobromae* has been found there, as well as in St Lucia.

Although our knowledge of canker has greatly increased in the past few years, and successful methods of treatment have been evolved, it would appear that additional information, especially in respect to the scientific details of the disease, is desirable. A large number of species of *Nectria* have been reported from different parts of the world as parasitic on cacao, and Petch in drawing attention to the position in Ceylon mentions that 'the *Nectria* on the stem is not the same as the *Nectria* on the pods. The former agrees with *Nectria striatospora*, Zimm.' Continuing further he states, that from Java, Zimmerman has recorded *Nectria coffeicola* and *Nectria striatospora* on cacao stems, and *Calonectria cremea* on cacao pods. In South America *Calonectria bahiensis*, Hempel, is found on the stem, while from the Cameroons, *Eunectria camerunenses*, Appel & Strunk, has been recorded.

In October 1906, a species of *Lasiodiplodia* was forwarded to this Department by Hart from Trinidad for examination, and a similar fungus has been recorded from Brazil and San Domingo. Last year (1907) this fungus was found associated with *Nectria theobromae* in cankered areas on cacao trees in Grenada, and recently Barrett has reported that it is common throughout Trinidad and may be responsible for a considerable quantity of the canker present in cacao plantations. *Diplodia cacaoicola* has been reported from Ceylon as causing a canker that differed considerably from that understood as the typical canker of Ceylon.

It will therefore be advisable that a brief review of our knowledge of canker in the West Indies as caused by *Nectria* or *Calonectria* should be given, and the remedial measures that have been found to be successful, indicated. Diseases caused by *Lasiodiplodia* sp., and *Diplodia cacaoicola* will be treated of separately.

Occurrence.—This disease is met with in Trinidad, Grenada, Dominica, and St. Lucia, and I have seen a few cases in St. Vincent.

Symptoms.—By the keen observer canker may be detected in its early stages. The bark of the affected areas presents a peculiar dry, greyish-brown appearance. The best time to look for these areas would appear to be in the dry season

immediately after a shower of rain. These greyish-brown areas do not dry as quickly as the unaffected portions of the bark, and the limits of the affected portions may thus generally be ascertained. If the bark is cut by a knife at these points, it will be found to be slightly discoloured, particularly in the outer layers. Later as the disease increases, the bark of these patches on being cut, presents a deep claret colouration. It is moist and soft to the touch, and if it is removed it will be found that the outermost layers of the woody tissues are affected.

Subsequently, these affected areas split or crack, and allow a brownish-red gummy fluid to ooze out. When this gum dries, it gives a dark rusty appearance to the bark. This is known as the 'bleeding stage,' and the disease is now well established.

In Dominica, cacao plants are often noticed that produce an abnormal number of flowers which never set fruit. This flowering may continue throughout the whole year, and is known as the 'flowering disease.' This, in Dominica, is generally one of the first symptoms of canker, for it has recently been demonstrated that such trees always eventually develop the disease. Whether this condition may satisfactorily be overcome by careful and high cultivation has yet to be demonstrated. A similar extraordinary flowering has been observed in St. Lucia, but it has not yet been satisfactorily ascertained whether it is common.

Canker may affect a branch or a stem, and frequently several spots may be noticed on the same tree. When these diseased areas are numerous, the leaves become small and assume a yellowish hue. The spread of the disease in the bark varies considerably. It may spread quickly round the tree, or may extend in all directions. Branches frequently die off through having become 'ringed,' and not uncommonly whole trees, particularly when the diseased area is near the surface of the ground, are killed. Undoubtedly, canker appears to be the more serious when it attacks the stem at about the level of the ground.

Frequently, under badly diseased cankered areas the woody tissues assume a dark-brown colour. Howard states that the tissues are penetrated by the mycelium of the fungus, but subsequent investigation would suggest that the fungal hyphae penetrate to but a slight distance in the woody tissues, and it is questionable whether they are directly parasitic on the wood.

In the rainy season the fructifications of the two fungi (*Nectria theobromae* and *Calonectria flavida*) may generally be found. White pustules make their appearance through minute cracks in the diseased bark and large numbers of conidia are produced, while subsequently colonies of perithecia make their appearance. They may be yellow (belonging to *Calonectria*) or red (belonging to *Nectria*), and contain the asci containing the ascospores. An exact knowledge of the life-histories of these fungi is not yet complete, and investigations will be continued.

Ripe ascospores have been found to produce infection, when introduced into wounds in the cacao tree, and it is generally held that these fungi are wound parasites.

It has been observed that canker is generally to be noticed more frequently among old trees, and it has rarely been observed on very young ones. A canker on trees six years old has recently been recorded from Dominica, which differs slightly from that above described in certain characteristics.

Spread.—As the fungi that are associated with this disease are held to be wound parasites, particular care should be taken with all wounds, both those made in pruning and gathering the crop, and accidental ones. If attention be given to all wounds, the spread of canker can rapidly be checked. Conditions of dense shade and abundance of moisture favour the spread of the disease, and should receive attention when remedial or preventive measures are under consideration.

Remedial Measures.—Considerable attention has been called to the methods used in combating this disease by officers of the Imperial Department of Agriculture and others, and therefore it is only necessary to summarize those which have proved most successful :—

All dead trees or branches should be cut out and burned. It is preferable that they should be burned on the spot if practicable, but if not, they should be removed to some heap to be burned. Suckers would appear to suffer but little from canker, and therefore it is often practicable to save suckers when a badly diseassd tree is cut down, rather than have to wait for the growth of supplies.

When canker spots are detected on the trees, the diseased bark and wood should be cut out with a sharp pruning knife, care being taken to remove at least a ½ inch of healthy bark around the diseased area. If the affected areas extend for a considerable distance around the stem of the tree, the bark must be removed in stages, or otherwise practically ring-barking may take place. It has been found that the bark from about a third of the circumference of a tree can be removed without seriously affecting nutrition, and after about three or four months more bark may be removed. Thus the gradual removal of diseased bark may be accomplished.

The wounds caused by cutting out the diseased tissues should be cleaned and thoroughly treated with tar. It has been recommended that a mixture of resin oil and manjak may be found to be a good substitute for tar. With this mixture, this Department has as yet had no experience, and therefore continues to recommend tar for application to wounds—a substance, when applied carefully and not allowed to run all down the bark of the stem or branches, that has given satisfactory results. After a tree has been treated, it should be marked by a ring of white-wash or white paint around one of the branches in order that it may be under careful supervision. The diseased portions that have been cut out should all carefully be collected and burned. They should, on no account, be allowed to remain on the ground at the foot of the tree, for disease may spread from them into the basal portion of the stem.

All knives or cutlasses used for cutting out diseased tissues should not be used for pruning purposes, and it is advisable that they should be disinfected before they are put aside. The treated trees should be inspected periodically and further, careful search for canker spots made. This part of the work will be greatly facilitated by the ring of white-wash or white paint that has been advised to be put around one of the branches of trees that have had canker areas removed from them.

The best time for canker work would appear to be during the dry season, for immediately after a shower the affected areas may easily be detected. Further, the wounds appear to heal more rapidly. It should, however, be mentioned that this work is not to be necessarily limited to the dry season, but should be carried on throughout the year, particularly on those properties where canker is at all prevalent.

Experience has shown that the above remedial measures will satisfactorily reduce the quantity of canker, if not entirely eradicate it. Estates, on which carefully conducted measures against canker have been carried out, have given increased crops, and the number of cases of canker has been very largely reduced. The beneficial results obtained by the adoption of remedial measures have repeatedly been noticed on various estates in the West Indies, and although accurate figures are not yet available, yet those available from the Experiment Stations in Ceylon, where somewhat similar measures have been practised, show conclusively that attacks of this disease may be rapidly reduced to a minimum.

In considering preventive measures, it must be borne in mind that the fungi associated with canker are regarded as wound parasites, and therefore one of the duties on the estate must involve careful attention to all wounds. Cuts made in pruning should be smooth and close to the stem or branch, and should be tarred over, and it may also be found possible that those made while picking can be similarly treated. A joint of bamboo, filled with tar, corked at the top end, and with a small spiket hole just above the lower node to allow tar to drain on the frayed lower end, has been found to be a convenient form by which tar may be carried when pruning operations are being carried on. It may be carried in the left hand, and after a branch or a sucker has been removed tar can immediately be rubbed on. This dispenses with the carrying of tins, does not allow of tar being put on to such an extent as to drain down the bark from the wound, and saves considerable time.

Canker is generally worse in plantations that are densely shaded, for the condition of moisture and of semi-darkness assists in the development of the fungi and in the dispersal of their spores. The reduction of dense shade in order to let in more sunlight is strongly to be recommended where disease is prevalent, for it has been found in Ceylon and in other places that this is a matter that should receive first attention. It is possible that the judicious thinning out of shade should receive attention on many West Indian plantations, but it must be adopted cautiously, for it has been observed that the direct rays

of the sun, in some dry localities, have the power of splitting the cacao bark and of causing wounds to which fungus spores may at a later date gain entrance.

It has been recommended that spraying should be adopted throughout cacao orchards to destroy fungus spores with a view to preventing infection, but experimental evidence as to the economy of such a practice for the spores of the fungi causing canker is yet to be forthcoming. Favourable results have been obtained in some orchards in temperate climates from spraying for canker of fruit trees, but no conclusive evidence has yet been obtained in tropical countries.

DIE-BACK.

This disease of cacao was investigated by Howard in Grenada and has subsequently received attention in St. Lucia and Dominica. In St. Lucia it was at one time particularly common, where it probably is the most serious of fungus diseases. It was very prevalent at low elevations on the light soils in the vicinity of sugar-cane cultivation, but can be entirely eradicated from a plantation by high cultivation and the general adoption of sanitary methods. A few cases have been noticed in St. Vincent. A similar disease, caused by the same fungus, has recently been reported by Petch from Ceylon, but does not appear to be very common.

Specimens of the fungus responsible for this disease were forwarded by Howard to Kew, where it was determined by Massee as *Diplodia cacaoicola*, P. Henn., a form reported on dead cacao branches in the Cameroons. This fungus is extremely common on diseased branches and twigs and is also found on cacao pods. Van Hall in Surinam reports a species of *Chaetodiplodia* on diseased cacao twigs, and it is possible that a similar fungus may be found to be associated with *Diplodia* in some of the West India Islands. *Diplodia cacaoicola* has been reported recently from Ceylon as responsible for 'die back,' and for a case of 'canker.'

Symptoms.—The disease commences in the younger twigs and spreads from them to the larger branches. The trees on which the young twigs have been killed, present an appearance that is known as 'stag-headed.' Sometimes cacao trees die back to a slight extent at the extremeties of the branches through poverty of soil, wind, drought, etc., but in such cases there is always a sharp line of demarcation between the dead and dying tissues. If, however, twigs that have been killed by the 'die-back' fungus are cut longitudinally, there is no boundary line between the living and dead tissues. The ends of the twigs are black and quite dead, and then an intermediate brownish-coloured zone is noticed between the dead and living tissues. Microscopic examination reveals fungal hyphae in this transition zone, which are at first colourless and then brownish.

In the rainy season, or even after a good shower, small blackish pustules will be observed to break through the bark. From these, the spores of the fungus may be obtained.

The life-history of *Diplodia cacaoicola* was worked out by Howard, who found that this fungus was parasitic on sugar-cane and on cacao in these colonies. The fungus is a facultative parasite and can live upon dead cacao wood, shells of cacao pods, and upon sugar-cane. The spores are produced in pycnidia just beneath the epidermis. They are produced on short conidiophores, and are unicellular, elliptical in shape, and colourless or faintly greyish. They are liberated from the mature pycnidia by means of the small ostiole at the apex. Soon after they are liberated, the exospore darkens and becomes dark-brown, and at the same time a transverse septum is formed across the shortest diameter of the spore. The colourless spores germinate more readily than the bi-cellular mature spores.

Spread.—Infection experiments conducted by Howard in Grenada point to this fungus being a wound parasite and capable of seriously affecting sickly trees.

The spores are spread by means of wind and rain, and it is only necessary for a wound to be present for infection readily to take place.

It has frequently been noticed that bad attacks of thrips and outbreaks of die-back disease frequently go hand in hand. Whether the thrips may make wounds through which the fungus can gain an entrance has yet to be demonstrated. This is a matter that should receive investigation.

Remedial Measures.—This disease does not readily attack trees in a vigorous condition of growth. Every effort should, therefore, be given to thorough cultivation, all diseased branches and twigs should be cut out and burned, and all wounds thus made should be followed by an application of coal tar or some similar substance.

It has been demonstrated in St. Lucia, by the work on the Experiment Plot at La Perle estate, Soufrière, that the disease may be defeated by high cultivation, manuring, and attention to careful pruning. The disease has practically been eradicated from this estate, and it is reported by Hudson that the yield of cacao has been increased from practically nothing to over 1,000 ℔. of cured cacao per acre, within six years. This fungus is not very destructive to carefully cultivated vigorous trees, so every effort should be made to improve the condition of all unhealthy trees.

Pen manures and mulchings should be applied, and all weeds should be carefully buried. All dead wood and twigs must be cut out of the plantation and burned. The cuts should be tarred.

It is also important that the husks or shells of all cacao pods should be buried with lime, for it has been shown that heaps of old pods lying unburied about a plantation serve as centres of infection for the spread of disease. It has been suggested that cacao shells may be treated with lime on the surface, but it would be preferable that they be buried, for experience has shown that such a procedure is the most sure and the most economical of all the

various methods that have been experimented with in checking the spread of the fungus that is responsible for this disease and for the 'brown pod rot.'

LASIODIPLODIA.

Towards the end of 1906, diseased specimens of roots and stems of cacao were forwarded to this Department from a Southern district of Trinidad for examination. It was found on examination that large numbers of septate, dark-coloured mycelial threads were present in the vessels of the roots, and in the vessels, medullary rays, and other cells of the stems. Fructifications were obtained in the laboratory, and the fungus was provisionally identified as a species of *Lasiodiplodia.* Specimens were then forwarded to the United States Department of Agriculture for confirmation of identification, with the inquiry as to the similarity between the Trinidad fungus and one under investigation by that Department from San Domingo and Brazil. The fungus on the stem was referred to the species of *Lasiodiplodia* reported as attacking cacao and mangos in Brazil and San Domingo but decision as to the identity of the fungus in the roots was reserved until development of cultures could render its recognition possible.

Further investigation in the laboratories of this Department has shown that the fructifications from the fungal hyphae in the roots appear to be identical with those procured from the stem, and it is more than probable that they were continuous throughout the tissues of the diseased trees.

This fungus was subsequently found on old cankered areas on trees in Grenada, and quite recently on diseased trees from several districts in Dominica. Barrett, while investigating the cacao diseases of Trinidad concluded that practically the whole of the disease in cacao orchards is due to a species of *Lasiodiplodia*, for it infects the fruits, the branches, and the stems by means of wounds and by means of the cushions from which the fruit-stems arise.

Our experience with this fungus has not been sufficiently lengthy to allow of investigations into the complete life-history to be carried out, and it has not yet been definitely established how infection may take place. Infection experiments carried on at Dominica showed that the fungus is weakly parasitic in habit, and, therefore, it may be supposed that infection might take place through wounds. Whether infection of the roots may take place, has yet to be established. In Trinidad it was supposed that the fungus spreads rapidly in the tissues, and consequently the disease kills off trees rapidly ; but experience in Dominica would indicate that the course of growth of the fungus is slow, for trees may be affected for some time before they are killed out. High cultivation and careful manuring have been beneficial in Dominica, but the fungus is generally to be found in districts where the soil is not particularly suited for the growth of cacao.

In Grenada, the fungus was obviously associated with canker, and appeared to be following old areas affected previously with *Nectria.* In Trinidad, canker is attributed to this fungus, as also is a disease of pods.

A scabby appearance of pods, in which small, blackish corky patches are developed on the surface at intervals has been observed in Grenada, and a similar appearance of pods has been found in certain parts of Dominica. The pods do not grow to quite the full size, but generally do not decay. The beans are often small and undeveloped. When such pods are placed in a damp chamber they invariably develop the fungus *Lasiodiplodia*, but it does not appear to have occasioned much damage.

Remedial Measures.—Until further information has been gained of this fungus, definite remedial measures cannot satisfactorily be indicated. Where trees are affected, as in Dominica, and present a dwarfed invigorous appearance with dying back of branches, and dark-black fructifications pushing through the bark, they may generally be cured by high cultivation, careful drainage, and manuring. Where the fungus affects the bark and produces a 'cankered' appearance, resource should be had to the remedial measures indicated above for the typical canker disease of the stem.

PINK DISEASE.

This disease was first noticed in certain localities of Dominica, but it has subsequently been found on some estates in St. Lucia. It does not at present appear to be of a very serious character and can satisfactorily be kept in check.

Symptoms.—The smaller woody branches of cacao frequently become covered with a pinkish incrustation of adpressed fungal hyphae. This, in younger branches, spreads all over the surface, while in the older branches it is usually to be found only on the surface of damper and more shaded sides.

Fungal threads from this pinkish mass push into the tissues of the bark, and may sometimes in small branches penetrate into the deeper tissues of the wood. The bark eventually cracks and splits, and then peels off. Generally it has been found that new bark has been formed, and it is not often that branches are killed off through fungal hyphae penetrating into the deeper tissues.

The fungus (*Corticium lilaco-fuscum*) that causes this disease is the more noticeable in damp, shaded situations, and during the rainy season, but cracked bark, showing where the branches have been attacked, is easily recognized during the dry portion of the year. The fungus may spread all over the surface of a branch and to other branches.

The chief danger of this fungus would appear to be that it causes cracks in the bark of the affected branches that serve as wounds for the entrance of spores of *Nectria*, *Diplodia*, etc, and, therefore, unless it is kept in hand, it may be the means of assisting the rapid spread of diseases throughout the plantation.

It should also be noted that another species of *Corticium*, viz.—*Corticium Javanicium*, Zimm., is reported upon many kinds of trees from Java, Ceylon, and Southern India. It destroys the bark, and kills small branches. Larger branches are not so badly affected, but it initiates canker.

Remedial Measures.—The fungus may be destroyed by washing the affected branches with a lime-sulphur wash. This may be made by mixing 7½ lb. of slaked lime with 2½ lb. of flowers of sulphur in 10 gallons of water, and boiling until the mixture turns orange in colour. When cold this mixture should be well rubbed on the parts of the branches affected.

All the younger branches that have been killed out should be cut off and burned, and even some of the larger ones it might be advisable to remove.

THREAD BLIGHTS.

Thread blights on cacao were first found in St. Lucia in 1904 and were described by Lewton-Brain at the fifth Agricultural Conference held at Trinidad in 1905. They have also been found in Trinidad, Dominica, Tobago, and British Guiana. During last year several different thread blights on a variety of plants were forwarded for examination to this Department from Trinidad.

Symptoms.—Thread fungi generally consist of sterile mycelial threads or strands of various colours running irregularly up and down on branches and stems, and closely adpressed to the bark. The delicate strands of mycelium sometimes form swellings before branching takes place. They generally spread upwards over all the younger twigs and buds, and then not unfrequently pass to the leaves, and appear on their under surfaces in the form of a network of fine filaments. Where two leaves touch, these filaments spread from one to the other, sometimes forming a thickened cushion at the point of contact.

Microscopic examination of these mycelial strands shows that they are composed of parallel-running fungal hyphae closely woven together. From the under side of these strands, numerous hyphae are given off into the bark of the twigs, and in the case of young twigs they penetrate through the cortex into the deeper tissues—thus causing the death of the attacked portions. Similar hyphae also penetrate from the strands on the under surface of the leaves into the deeper tissues and also into the tissues of buds. Leaves and buds may, therefore, also be killed by the fungus.

Specimens of different thread fungi have been carefully examined, and it has been found that the mycelial threads are not composed of similar hyphae. It is extremely probable, therefore, that these thread blights do not represent the same fungus in all cases. Fructifications have not yet been obtained, but it is possible that some of them belong to the Basidiomycetes, for clamp-connexions have been frequently noticed.

'Horse hair blight' resembles closely a tuft of horse hair caught in the twigs. Some of the threads are closely attached to the bark, and send in hyphae into the deeper tissues of the branches. Specimens of horse hair blight have been sent by Hart from Trinidad to Kew for identification. The fungus was determined as *Marasmius equicrinus*, Mull.

Spread.—The chief method of spread is by means of the threads on dead twigs, leaves, etc., being blown or caught in the branches of healthy trees. In India, thread blights have been spread from jungal trees on to tea, while in Ceylon similar diseases are known on nutmegs and tea. In Java these have been found upon coffee.

Remedial Measures.—Thorough and constant pruning and burning of all diseased material appear to have kept the disease in check in St. Lucia. It is still occasionally found in damp, shaded portions of plantations, but does not threaten to be a serious disease. All wild trees near cacao plantations that are affected with thread blights should be pruned back, so as to avoid the danger of spread of the disease from them to the cacao, and shade should sometimes be reduced. Applications of lime and sulphur wash, as recommended for 'pink disease,' to the fungal threads are also recommended, where heavy prunings cannot satisfactorily be given.

WITCH BROOM DISEASE.

This disease has proved most serious in the cacao plantations of Surinam and has been under most careful investigation by the agricultural authorities there. It has recently been reported from one or two localities in British Guiana, and has been found in a single instance in Trinidad.

Symptoms.—The symptoms are well known. The twigs are affected in the bud state. Hypertrophied growth takes place and there is a tendency towards making many side branches, and producing clusters of twigs resembling brooms. The fruits are also affected by the fungus. When young they often show a small swelling on one side, which frequently may be rather difficult to detect except by the trained eye. At other times simply a discoloured spot is noticed, which later, as the tissues die, becomes black. The pods do not grow to a normal size, but become excessively hard. This symptom the planters call 'petrification,' and affected pods may easily be distinguished from pods attacked by other diseases.

The fungus responsible for this disease was described as *Exoascus theobromae*, Ritz Bos, but the characteristic fructifications of this fungus are extremely difficult to find. It has however been shown that the witch broom of the twigs is caused by the same fungus as the 'petrifaction' of the fruits.

Remedial Measures.—The disease has done a considerable amount of damage in Surinam, and efforts have been made to find measures of control. A heavy pruning of all infected trees and spraying with Bordeaux mixture have been given a careful trial, and some encouraging results have been obtained. If the experiments continue to be successful, they may lead to important conclusions towards solving a problem of great moment to that country.

This disease has not yet made its appearance in any of the West India Islands, and every effort should be made strictly to enforce the Plant Protection Acts that have, within the last few years, been passed to prevent the spread of diseases throughout these colonies.

POD DISEASES.

BROWN ROT.

This disease occurs in all cacao-growing districts of the West Indies. It was first investigated by Howard in 1901 in Grenada, and has been noted in St. Lucia, Dominica, St. Vincent and British Guiana. In some instances, particularly when weather conditions were favourable for the spread of the fungus, it has occasioned considerable damage, but it has been demonstrated that properly conducted preventive and remedial measures will easily keep this disease in check.

Symptoms.—The brown rot of cacao pods is caused by *Diplodia cacaoicola*—the same fungus as the die-back disease of the stem. The disease commences as a small, brown, almost circular spot at either end of the pod or along one of the grooves. It is most commonly seen to commence from the basal end of the pod attached to the tree. This brown decay spreads rapidly all over the pods, destroying the rind. Subsequently it spreads into the centre of the pods and destroys the cacao beans, which are enveloped by a greyish-brown mass of fungal mycelium. The pods are usually soft and rotten, and eventually fall from the trees. Diseased pods are generally the more common near the 'breaking places' particularly on those estates on which burial of husks or shells is not greatly practised.

From the brownish coloured diseased areas small pustules may be seen bursting through the rind of the pods, and emitting a greyish-white powder. These are the unicellular, colourless spores of *Diplodia cacaoicola* and subsequently they become bi-cellular and dark brownish-black in colour. The whole pod eventually becomes black from the mature spores given off from the numerous pustules.

Investigation has shown that this fungus on the pods is identical with the one that causes die-back of the stem, and infection experiments carried out by Howard, and subsequently repeated, show that it is parasitic in habit. The fungus is frequently found upon old cacao husks, and therefore is grouped with the facultative parasites.

Remedial Measures.—This disease may readily be kept in check by collecting all diseased pods and burying them, together with all husks and shells, with lime in trenches or pits. Ripe pods that show the brownish diseased areas should at once be picked in order to save as many of the beans as possible.

Experience in most of the West India Islands has shown that the burial of husks and diseased pods is a means of checking the disease, and owners of estates that have followed this practice will testify to the considerable reduction in diseased pods. Some estates in Grenada and St. Lucia have greatly reduced their losses by adopting the above measures.

It has been suggested that treatment of shell heaps with lime on the surface might be equally as effective, but evidence on this point has yet to be obtained. It is doubtful, however,

whether such a system could be as strongly recommended as burial.

This disease is still very common in several parts of the West Indies, and is generally to be found in damp, shaded situations. It is possible that some reduction of overhead shade may, in some instances, be productive of beneficial results.

An epidemic of the disease could be checked by spraying the pods on the trees of a plantation with Bordeaux mixture, after the most badly diseased ones have been removed. Spraying for pod diseases has been experimented with by Wright at the Experiment Stations in Ceylon, and it was found that the number of fungus-attacked pods could considerably be reduced by systematic spraying, and that the increase in the crops showed considerable profit above the expenditure incurred by the operations. It was stated, however, that the results of different experiments showed that spraying could only be advised for the fruits, and should be carried out at the setting of the young fruits or during crop time.

BLACK ROT.

This disease is common in Trinidad but has also been found at St. Lucia, St. Vincent, and British Guiana. Attention was first called to it by Hart in 1898, when it was found that a larger percentage of the crops in many districts in Trinidad were being destroyed. Investigations by the Botanic Department of Trinidad, and by Kew showed that the disease was due to the fungus *Phythophthora omnivora*, De Bary.

Symptoms.—The attacked pods turn black and are then covered with the white mycelium of the fungus which produces larger numbers of ovate conidia. These may be carried by rain or wind to other pods, and if conditions are suitable they may germinate at once, penetrate the tissues and further produce the disease. The mycelium of the fungus spreads rapidly in the substance of the pod, and resting spores (oospores) are formed by a sexual process—thereby enabling the fungus to satisfactorily tide over periods that may be unfavourable for its growth. These oospores are liberated on the decay of the fruit, when they germinate and start the disease again.

The pods affected by this disease usually assume a dense black colour, become hard, and often hang, covered in places with white fungal mycelium and conidia, on the branches for a considerable period before they fall.

Remedial Measures.—Diseased pods should all be collected and buried with lime in order to destroy the superficial conidia and the deep-seated oospores of the fungus.

It is advisable also that all husks and shells, as advised in the remedial measures given for the 'brown pod rot,' should be buried with lime. A reduction of shade might be practised in some localities, for too moist and shaded a situation favours the growth of the fungus and the spread of the disease.

In epidemics, spraying with Bordeaux mixture should be resorted to, and on those estates where this disease is generally prevalent carefully conducted experiments to ascertain how much disease may be prevented by periodic and systematic sprayings should be carried out.

The adoption of the removal of all diseased pods and burial together with husks with lime has been general on many Trinidad estates, and the extent of the disease has been considerably reduced.

SCABBY POD.

Cacao pods showing small, irregular brownish-black corky areas produced at intervals all over their surfaces have on several occasions been forwarded to this Department from Grenada. Others have also been found in Dominica. These pods do not grow to full size and the quality of the beans is poor.

Microscopic examination of these corky areas showed the mycelium of a fungus beneath them, but it could not be ascertained whether this mycelium extended to any considerable depth in the tissues. On placing the pods, however, in a damp chamber, fructifications of a species of *Lasiodiplodia* always made their appearance and, therefore, this peculiar appearance of the pods will receive further attention.

Further investigation will be conducted into the nature of this disease, and its economic importance endeavoured to be ascertained. At present, however, it does not appear to be very common, nor does it seem to occasion much damage.

NECTRIA.

In 1898, Hart sent from Trinidad pods affected by *Nectria Bainii* to Kew for examination. This supposedly parasitic fungus does not appear to be very common. It causes 'semi-circular dark blotches to appear on the pods, the diseased portion becoming soft and watery.' Later these become covered with a yellowish and orange-coloured mycelium, from which are given off small red perithecia.

During investigations in Dominica, St. Lucia, and St. Vincent, species of *Nectria* were very rarely found upon living cacao pods and these did not always belong to the same species. A further investigation into the life-history of this fungus and into its distribution, as well as of other species of *Nectria* found on cacao, will have to be carried out before it can definitely be stated whether *Nectria Bainii* is of great economic importance.

Remedial Measures.—The measures recommended for the control of the brown or the black rots of pods would probably be effective in keeping any outbreak of this fungus in check.

SANITATION OF CACAO ORCHARDS.

Having given descriptions of the several fungus diseases of cacao in the West Indies, it is here intended to indicate as briefly as possible the principal points for consideration towards maintaining the health of the trees and preventing disease.

A considerable amount of knowledge of the life-histories of many of the fungi parasitic on cacao has been gained during the past few years, and efforts have been made to fight the different diseases. In many cases, however, further inquiry into the life-histories of the fungi under consideration is still necessary, in order to ascertain when the direct remedial measures may be employed with the best prospect of success. Additional investigations will have to be made in order to elucidate clearly the relations that exist between the various parasites and the cacao tree. Further study must also be made of the remedial measures against these diseases in order to assure that the most direct and economical methods are being adopted. Subsequently, a thorough scientific investigation of the different species of the fungi on cacao —saprophytic as well as parasitic—will have to receive attention.

If the remedial measures given above for the various diseases are carefully studied, it will be observed that it is recommended that considerable attention should be given to careful and thorough cultivation. Results obtained on the experiment plots of the Imperial Department of Agriculture established in the various West India Islands, have shown that high cultivation and judicious manuring are followed by the best returns. Expenditure on tillage, drainage, and manures is followed by increased profits, and the vigour and health of the trees are improved.

For the supply of humus for cacao estates it may be found necessary in some localities in these colonies to set aside areas on the estates for the growing of grasses, or leguminous crops, that may be used in the plantations either as mulch or in the form of pen manure.

It has frequently been observed by scientific workers in other countries that when conditions of soil or climate are such as to interfere with vigorous and healthy growth, changes may take place in the tissues of the host plant which may favour the development of the fungus and enable it to do considerable damage with great rapidity. Healthy development may, on the other hand, assist the plant in resisting attacks of fungus or making its inroads unimportant.

Pen manures have been found to be especially valuable, and the healthy vigorous condition of trees after the adoption of mulching and the judicious use of weeds both in Dominica and in St. Lucia can but recommend this practice for consideration at the hands of cacao planters.

Careful attention should be given to pruning and to canker excision. Several of the fungi of the cacao tree are wound parasites, and therefore it is necessary that all wounds whether

made by pruning, or caused accidentally, should be looked after. In pruning, it is necessary that the cuts should be as near the main trunk or branch as possible. They should be smoothed off with the pruning knife and should all be coated, as soon after the cuts are made as possible, with an application of tar, paint, resin oil and manjak, or some similar mixture. Tar has been largely used in the West India Islands and has proved generally satisfactory. Care must be taken, however, that it is not allowed to be smeared down the bark of the trees, for it appears to have some injurious effect upon it and upon the flower shoots that are given out. When confined to the cut surface of the wound, it answers well, especially if applied during the dry season. Canker excision for this reason, as well as for several others—such as ease of detection of cankered areas, less active flow of sap, and greater rapidity of wound healing—should be carried out during the dry months. The important work, however, should not necessarily be confirned to this period, particularly on estates where the disease is prevalent.

Care should also be exercised during picking, for many of the wounds made during this operation, particularly by the cacao hook, have been sufficient for canker to commence in.

All suckers, except where they are needed for use in shaping the tree or for replacing it, should be removed periodically and the cuts tarred. It has been experienced in Ceylon and also in the West Indies that suckers are sometimes less liable to canker than old trees, and therefore it is often possible to save a sucker or two from the basal portion of the tree to take the place of the diseased tree when it is removed. The adoption of this plan makes it possible frequently to replace a diseased tree in a shorter time than would be required by the growth of young supply plants.

Wounds caused by the falling of portions of shade trees or of bananas and plantains should always receive immediate attention, and all the injured branches should be removed. The wild plantains, such as the cokoi of Dominica, appear to suffer less from wind than the cultivated varieties, and are useful in the establishment of young cacao cultivations.

Dead branches caused by the falling of trees or plantains above referred to, and all branches killed out by either *Diplodia*, canker, or root disease should be cut out, removed from the plantation and burned. Many of the fungi of cacao are facultative parasites and can live and increase upon these dead branches and twigs if they are allowed to remain on the estate. Diseased bark excised when treating canker should also be collected and burned. It should never be allowed to remain at the base of the tree from which it has been cut.

All diseased pods, and husks of pods after they have been broken, should be collected and buried in pits or trenches with lime. It has been found that such procedure is productive of the best results, and should be adopted until experimental evidence is forthcoming as to the value of the suggested treatment of such pods and husks upon the surface of the soil.

Cacao should always be protected from wind. Wind-swept orchards suffer more from disease than do well protected ones. The trees are not so vigorous. Nor do they bear so heavily. Wind belts should be established throughout plantations where necessary. Pois-doux and galba are useful for this purpose, but in some cases overhead shade of bois immortel is relied upon for protection from wind. In St. Lucia, several instances of shading with bois immortel has been productive of much good on estates suffering from 'die-back,' but it must also be recorded that in several localities in some of these islands some reduction of shade might judiciously be made, for a moist atmosphere and densely shaded conditions are extremely favourable for the development and spread of fungi. It has frequently been found in some parts of Dominica and St. Lucia that the gradual removal of shade trees, or of some of their branches, has served as a factor in the control of canker. In Ceylon, the letting in of sunlight is strongly recommended, but it is necessary in the West Indies that it should be adopted cautiously, until experimental evidence is forthcoming, for quite a number of factors have to be taken into consideration.

Where cacao trees, pois-doux or other trees in the orchards die from root disease, they should immediately be removed and burned. The roots should be extracted, and burned with the stems and branches. Trenches should be dug around the affected areas, and large applications of quick lime should be given. The fungicidal properties of quick lime have yet to be fully appreciated, and the use of this substance is valuable in the control of the root disease. Drainage should also be attended to, for root disease has been noticed to be generally worse on water-logged, low-lying soils. The susceptibility of bread-fruit, bread nut, and certain other trees to attacks of the fungus responsible for root disease of cacao would suggest that these trees should be excluded from all new plantations of cacao.

In those plantations where they are at present growing, they should be carefully watched, and when showing any signs of disease should be taken out and burned. When it is thought desirable, at any time, to cut down any of these trees, particular care should be taken thoroughly to extract as many roots as possible and to destroy them by burning.

Spraying for pod diseases has been experimented with in Ceylon and the results warrant experiments being conducted on West India estates as a means in the prevention of similar diseases. A good trial should be given, and accurate figures of the increased expenditure incurred in carrying on such operations should be kept for a series of years. Definite information as to the value of spraying for prevention of pod diseases would then be available, and would indicate whether such operations should be generally adopted as routine estate practises.

In conclusion, it should be added that considerable information in respect to diseases is available for the cacao planter, and trials of remedial measures have shown that they

are all practically amenable to treatment. Further investigations are in hand and it is expected that additional knowledge of the different fungi will shortly be forthcoming. It must be pointed out, however, that the mycologist must always occupy more or less the position of the 'specialist,' while the various agricultural instructors and the planters themselves must be the 'general practitioners.' They should adapt the suggestions for remedial measures to suit local conditions and they may render valuable service to an important section of West Indian agriculture by recording observations on diseases and their treatment, for the information and guidance of Agricultural Authorities.

NOTE ADDED:—While this paper was passing through the press, the technical description of *Nectria theobromae*, Massee has been published in the *Kew Bulletin* No. 5, 1908. It is here reprinted, in order that comparisons may be made with the description of *Nectria Bainii*, Massee, given in *West Indian Bulletin*, Vol. 1, p. 425:—

'*Nectria theobromae*, Massee,—*Perithecia* gregaria vel sparsa, superficialia, ovata, levia, glabra, aurantiaca-hyphae rubescentia, ostiolo minuto vix prominulo hiante, 0·5 m.m. alt. *Asci* cylindracei, stipitati, octospori, paraphyses septate, ascos excendentes, hyalini, apice vix incrassato, interdum flexuoso, 8 Microns crasso. *Sporae* obligue monostichae, hyalinae, ellipsoideae, 1-septate, ad septum subconstrictae, 28-30 × 8-10 Microns G. Massee.

'This appears to be one of the various species of parasitic fungi that form bleeding wounds in the bark of the cacao tree. *Nectria Bainii*, Mass., previously described as forming similar wounds on cacao pods, differs from the present species in having the perithecia shaggy with golden-yellow scale-like hairs.'

DISCUSSION.

Hon. E. G. BENNETT (St. Lucia) said he had been very much puzzled in determining certain diseases that had been affecting his cacao estate, which was situated in the Cul de Sac district, but from the descriptions given by Mr. Stockdale, he was satisfied now, that besides thrips and canker, his trees had been suffering from attacks of 'root disease' and 'die-back.' One peculiarity of 'die-back' was, that notwithstanding manurial treatment and application of remedies recommended, there was a periodical appearance of the disease just about the time that the cacao was approaching maturity. With regard to thrips, whether they preceded *Diplodia* or followed it, he was not sure, but his experience was that he noticed *Diplodia* long before he observed the thrips. Since reading the interesting papers by Dr. Watts on the subject of mulching, which had been published in the *West Indian Bulletin*, he had

commenced to mulch his trees, but had not been doing so sufficiently long to arrive at any accurate statement as to results.

Hon. J. G. W. HAZELL (St. Vincent) asked what kind of tar was used for application to wounds made by pruning.

Mr. STOCKDALE replied that coal tar was generally used, and mentioned that care should be taken in its application. It should be confined to the wound itself, and should not be smeared over or allowed to run down the bark of the tree.

Mr. A. R. C. LOCKHART (Dominica) said that his experience was similar to Mr. Bennett's. Trees that had been perfectly healthy for several years suddenly developed disease. The belief of the common people in Dominica was that the disease was the result of the tap root of the trees coming into contact with some unsuitable layer of soil. What that was worth he did not know, but he mentioned it for what it was worth.

Hon. W. FAWCETT (Jamaica) said that root fungus was more prevalent at Jamaica than anything else. It affected various kinds of coffee, cacao, logwood, and also West Indian cedar. It was necessary to isolate the trees and prevent the disease spreading from root to root, by digging the trenches to a depth of about 2 feet. He had observed trees dying here and there, and on examination, found that they were attacked by fungus. Knowing the history of the estates, he had called attention to the fact that the decaying roots of bamboos or the trees which had been cut down were left in the soil. He did not think however, that that alone would enable attacks of fungus to kill healthy cacao trees. The fungus might be there in the ground, but it could not do any harm unless it got a sudden increase of strength to enable it to attack the living trees around it, or the living trees themselves became unhealthy on account of some condition of drought or soil, and then the fuugus had power to attack a tree and kill it.

The PRESIDENT thought that Mr. Fawcett was quite right as to the root disease of cacao being of a similar character to the root disease that attacked coffee and other trees. It was evidently a fungus that existed in the soil and spread in the soil, and would possibly attack anything that came in its way and was suffering from want of vigour. The only remedy it seemed, was that when a tree was dead or dying, it should be taken up at once and the soil treated with lime. In some cases, like that of a cacao tree which had not gone too far, the roots should be examined, and those that were attacked should be cut out. Infected trees also should be isolated by digging drains around them so as to prevent the spread of the disease.

He would add that Mr. Carruthers, who at one time was Mycologist to the Government of Ceylon, after a careful study of the circumstances there, found that an essential part of the treatment of cacao canker was the letting in of sunlight amongst the cacao trees. This had subsequently been experimented with at the different Experiment Stations, sometime under the charge of Mr. Wright, and the results obtained

should be carefully considered by all cacao planters. The gradual reduction of shade had very frequently a distinctly beneficial effect in lessening the attacks of disease.

He might mention that the Government of Trinidad had recently engaged Mr. Barrett, of the United States Department of Agriculture, for the purpose of investigating the diseases affecting cacao trees in Trinidad. When Mr. Barrett's final report was sent in, he thought it would be desirable for the Imperial Department of Agriculture to go carefully into the whole question and prepare a summary of the circumstances stated by him, and the recommendations made by him, and put them on record.

He also alluded to the danger of introducing cacao beans from one colony to another from the disease point of view, and strongly urged that no cacao should be introduced for planting purposes from the continent of South America, owing to the presence there of the 'witch broom' disease. Most of the colonies had Plant Protection Laws, but the greatest caution should be exercised against what has proved to be a most terrible disease of cacao orchards.

CACAO THRIPS.

BY H. A. BALLOU, M.Sc.,

Entomologist on the Staff of the Imperial Department of Agriculture.

The cacao thrips is probably familiar to every grower of cacao in the islands where this insect occurs. Since it first appeared as a pest in Grenada it has been more or less prevalent from time to time in different places.

It has been found that thrips becomes numerous enough to attract attention only when, for some reason, the cacao trees are not in the most vigorous condition of growth.

Some of the influences which tend to reduce the vitality of the cacao trees and thus render them more susceptible to the attacks of thrips may be mentioned—seasons of drought, lack of drainage, lack of tillage, lack of fertility and of humus in the soil; and, in fact, anything which causes a check in the growth or produces an unhealthy condition of the trees is liable to promote the development of thrips.

On the other hand, anything that tends to improve in a general way the vigour and healthfulness of the cacao trees would be expected to assist in reducing and keeping down the number of thrips. In all cases where it has been tried it has been found that any improvement of the conditions of the trees that are suffering from thrips results in diminished numbers of, and lessened injury by, these insects. This improvement may be brought about by attending to drainage, by better cultural methods, such as tilling the soil, pruning out dead wood, improving the soil by the addition of manures and humus to give greater fertility and better aeration, and to increase the moisture-retaining properties in times of drought. Experiments in Grenada, St. Lucia, and Dominica have all given results bearing out these statements, and from observations on estates where, although no experiments have been carried out, improved cultural measures have been adopted, it has been found that attacks of thrips have been less frequent and less severe, and in certain instances thrips' attacks have ceased or have become much reduced with the advent of rains after a drought.

The description of cacao thrips, its habits and manner of attack, and the remedies to be used in its control have appeared in the publications of the Imperial Department of Agriculture (*West Indian Bulletin*, Vol. II, pp. 175, 289; Vol. III, p. 235; Vol. VI, p. 94,; Vol. VIII, p. 148; *Agricultural News*, Vol. III, p. 90) and are only briefly reviewed here.

Thrips are small insects of the order Physopoda. The cacao thrips (*Heliothrips* [Physopus] *rubrocincta*) is from $\frac{1}{18}$ to $\frac{1}{25}$ inch in length. The adults are dark-brown or black, the young are pale-green or yellowish-green with a bright-red band across the abdomen. These insects make minute incisions in the plant tissues on which they feed. They are generally to be

found onthe under surfaces of the leaves and on the pods. They injure the plant by feeding on the sap, and the incisions made by them may afford entrance to fungoid diseases.

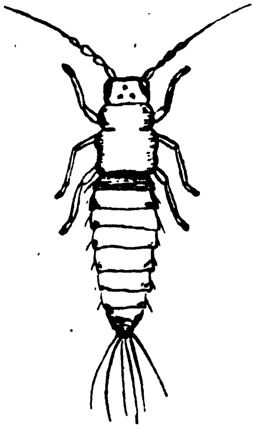

FIG. 1.
Young 'Thrips.'

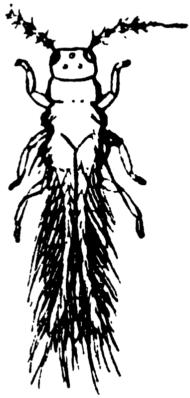

FIG. 2.
Mature 'Thrips.'

The pods are discoloured by these attacks, and it often happens that pods picked as ripe are merely discoloured. This sometimes occasions considerable loss. This however is less a source of loss than formerly, as cacao pickers are learning to be careful, and discoloured pods in thrips-infested areas are tried, before being picked, by scratching or slightly cutting the surface so that the tissue just under the skin can be seen.

It will sometimes happen that cacao thrips will occur in such abundance that it is desirable to spray to bring them under control as quickly as possible, while the effects of cultural methods are becoming apparent. For this purpose any of the sprayers of the knapsack or barrel types might be used. The following mixtures are recommended as being useful in this connexion:—

1. Rosin Wash.

Powdered rosin	4 lb.
Caustic soda (77 per cent.)	1 „
Fish oil	¾ pint.

Mix these, cover with about 2 inches depth of water, and boil till all is dissolved. Then add water *very slowly* to the liquid, keeping it continually boiling until the whole is made up to about 3 gallons. This is stock solution. For use, add 6 gallons of water to 1 gallon of stock solution.

Amount of wash, 21 gallons.

2. *Kerosene Emulsion.*

Hard soap	½ lb.
Kerosene	2 gallons.

Boil the soap in 1 gallon of water till it is dissolved. Take it off the fire, at once pour in the kerosene and churn the mixture with a force pump or syringe for ten minutes. This is stock solution. Add 9 gallons of water to 1 gallon of the stock solution.

Makes 30 gallons.

3. *Kerosene Emulsion with Whale Oil Soap.*

Use 1 lb. whale oil soap in place of ½ lb. hard soap and make and use as in No. 2.

4. *Rosin and Whale Oil Soap Compound.*

Rosin	4 lb.
Washing soda	3 „
Whale oil soap	10 „

With the rosin and soda make 4 gallons of rosin compound stock solution as above. Stir the whale oil soap in 5 gallons of hot water; mix the two while hot. This is stock solution. To every gallon add 4 gallons of water. An alternative method is to make the rosin compound stock solution. For use, mix 1 gallon with 10 gallons of water and stir in 2½ lb. of whale oil soap. Every 45 gallons of wash should contain the above ingredients, however mixed.

Of these, Nos. 1 and 3 are recommended as likely to be most effective.

DISCUSSION.

Hon. H. GRAHAME LANG (Grenada) said that in Grenada some years ago they suffered badly from attacks of thrips; but now they had found that whenever thrips appear, it was due to some cultural defect. As soon as the land was well tilled, the thrips disappeared. The chief cause was want of a system of proper drainage. To get rid of thrips a good system of cultivation must be adopted. The burial of husks or shells should also always be insisted upon on cacao estates.

Mr. J. H. HART (Trinidad) said that their experience of thrips was that it was a matter of no consequence whatever to cultivations in Trinidad. There was some there, but they attributed their comparative freedom largely to the presence of shade.

LIME JUICE INDUSTRY.

CITRATE OF LIME AND CONCENTRATED LIME JUICE.

Dr. Watts, Government Chemist and Superintendent of Agriculture for the Leeward Islands, briefly reviewed the position of the Lime Juice Industries of Dominica and Montserrat:—

During the past year little additional information had been obtained and reference should be made to the article prepared for the last West Indian Agricultural Conference and published in the *West Indian Bulletin*, Vol. VIII, pp. 167-9.

Concentrated juice prepared from lime juice that has been carefully strained and then settled, after distillation, has obtained a special market for direct use in various arts and manufactures in the place of crystallized citric acid. It commands relatively higher prices than ordinary concentrated juice, and therefore every effort should be made by planters to ship a high-class product.

The use of centrifugals in drying citrate had given very good results. Centrifugal-dried citrate contained much less water than the ordinary pressed product, and was in a better physical condition. Samples of different types of citrate now exhibited show clearly the better condition of the centrifugal dried citrate and would indicate when citrate of lime is made on a large scale the use of the centrifugal instead of the press is to be recommended.

Mr. Joseph Jones, Curator of the Botanic Station, Dominica, gave the following information in respect to the progress made in the manufacture of citrate of lime in Dominica during the past year:—

During 1906, the year in which citrate of lime was first exported from Dominica, 728 cwt. of this product were exported. During 1907, 2,388 cwt. of citrate of lime were shipped, showing an increase over the export of 1906, of 1,660 cwt., a very satisfactory advance.

Up to the present time only one firm has been engaged in making this product, but it is probable that another estate may shortly commence its manufacture.

The great drawback in making citrate in Dominica at present is the cost of drying the product. What is required is efficient machinery for cheaply and quickly drying the citrate without loss of acid. When such an apparatus can be obtained without too great a cost, the chief obstacle in the making of citrate of lime by estates will have been removed.

Should such machinery be of too costly a character for estates making 80 to 100 hogheads of concentrated juice to

instal, then we may expect to see the development of factories at suitable points in the several districts for the purchase of lime juice from adjoining estates to be made into citrate of lime.

Information as to the cultivation of the lime and to the manufacture of its products has been prepared in co-operation with the scientific officers on the staff of the Imperial Department of Agriculture, and will shortly be issued in pamphlet form.*

[* A B.C. of Lime Cultivation, Pamphlet, No. 53, issued in March, 1908. Ed. *W.I.B*].

WEST INDIAN AGRICULTURAL CONFERENCE, 1908.

(CONCLUDED.)

COTTON INDUSTRY.

RECENT RESULTS IN THE CULTIVATION OF COTTON AT BARBADOS.

BY J. R. BOVELL, I.S.O., F.L.S., F.C.S.,

Superintendent of Agriculture, Barbados.

In the paper on the cotton industry in Barbados which I prepared for the last Conference, I stated that judging from the results so far obtained, the best time to plant cotton in Barbados in the black-soil districts, that is on the lower levels of the island, was from the middle of June to the beginning of August, and in the red-soil districts, on the higher levels, from about the beginning of August to the middle of September. Another year's experience with this crop confirms this statement. When cotton is planted late in the rainy season, the rainfall ceases before the plants are sufficiently matured to bear an abundant crop. On the other hand, speaking generally, when the seed is sown sufficiently early in the rainy season for the plants to be benefited by the rainfall and they are protected from the attacks of the cotton worm, they are vigorous and healthy when bolling time arrives, and good crops are obtained. Occasionally, cotton crops planted out of season have given good results, but these are exceptional.

The manurial experiments which were instituted in 1902, a full description of which was given in the above-mentioned paper, (*West Indian Bulletin*, Vol. VIII, pp. 173-8) were carried out on two estates during the season 1906-7. Unfortunately, on one estate, owing to the fact that the division stakes were stolen, the overseer in charge of the gang picking the cotton allowed them to cross the boundary

line between certain of the plots. The results therefore cannot be taken into consideration. On the other estate, owing to the unfavourable weather conditions which prevailed during the time the crop was grown, and which caused a number of bolls to drop, the results are inconclusive. I may, however, state that the best results were obtained on the plots which received 30 lb. of nitrogen (N) as sulphate of ammonia, 60 lb. of phosphoric acid (P_2O_5) as superphosphate, and 20 lb. of potash (K_2O) as sulphate. The value of the increase over the plot which received no manure was \$7·77, and that which received only phosphoric acid and potash \$13·32. It may here be stated that last year the plots which received the same quantities of manure gave the second best results.

In the paper prepared for the last Conference, I gave the monetary results obtained with cotton crops grown on four estates, three in the parish of St. Philip, in which the largest area is planted with this crop; and one in the parish of Christ Church. Through the courtesy of the gentlemen in charge of these estates I am again able to give this year the results obtained during 1907. (See Appendix.) As will be seen therefrom, the results owing to the unfavourable weather conditions, have been barely satisfactory, and had it not been that the price of cotton was above the average, the cotton crop would probably in two instances, have resulted in a loss. The following is a summary of the results on these estates for 1907, compared with the results obtained in previous years:—

ESTATE NO. 1.

Three years' (1903-6) crop.	Average area ...	53 acres.
Average profit per acre per annum	...	£9 17*s.* 10*d.*
Crop of 1907.	Area	110 acres.
Average profit per acre	... ...	£2 0*s.* 3*d.*

ESTATE NO. 2.

Crop of 1906.	Area	17 acres.
Average profit per acre	... ...	£14 8*s.* 6*d.*
Crop of 1907.	Area	46 acres.
Average profit per acre	... ...	£2 19*s.* 7*d.*

ESTATE NO. 3.

Crop of 1906.	Area	16 acres.
Average profit per acre	... ...	£9 8*s.* 11*d.*
Crop of 1907.	Area	30 acres.
Average profit per acre	... ...	£2 7*s.* 1*d.*

ESTATE NO. 4.

Crop of 1906.	Area	34 acres.
Average profit per acre	... ...	£11 8*s.* 8*d.*
Crop of 1907.	Area	100 acres.
Average profit per acre	... ..	£7 9*s.* 4*d.*

In spite, however, of the diminution in the yields of cotton for the season 1906-7, the area planted in cotton in Barbados has been increased from 5,000 to 6,935 acres.

The following is a table showing the area of cotton planted and the quantity and value of lint exported from Barbados from 1902-8 :—

Year.	Average.	Quantity of lint in pounds.	Quantity of seed in pounds.	Value of lint.	Value of seed at £5 per ton.	Total Value.
1902-3	16	5,550	13,450	. .	...	£318
1903-4	800	192,061	472,510	£12,388	£1,055	13,443
1904-5	1,647	344,232	846,882	20,869	1,890	22,759
1905-6	2,000	479,418	1,179,468	30,363	2,633	32,996
1906-7	5,000	852,408	2,042,840	72,326	4,560	76,876
1907-8	6,935	1,387,000*	3,317,121*	104,025*	7,404*	111,420*

* Estimated.

There is one matter in connexion with the cotton industry in Barbados, which although receiving some attention at the hands of a few of the growers, has yet to be taken up by the majority of them, and that is the question of seed selection. This question is, as I said last year, of vital importance to the cotton growers in the West Indies, and unless growers regularly and systematically select seed for planting from the healthiest and best plants, the quality and yield will rapidly deteriorate. In 1906, the Imperial Department of Agriculture, through Mr. Thomas Thornton, Travelling Inspector in connexion with Cotton Investigations, carried out seed selection on seven estates. On the seven estates, 264 plants were selected, and of these, only fourteen were finally judged to be entirely satisfactory. For the season 1906-7, seed selection has been carried out on ten estates, and 224 plants were selected in the field. Of these, twenty-six were ultimately selected. It is with pleasure that I now report that cotton picked from plants grown from the seed selected in 1905-6 is excellent in every respect.*

* Seven bales of cotton from No. 303 (*West Indian Bulletin*, Vol. VII., p. 159) have been reported upon by Messrs. Wolstenholme & Holland as follows : 'It is the most serviceable class of cotton produced in the West Indies, and if it gives a better yield per acre than the finer descriptions—as it probably will—we think it is more suitable for extensive cultivation.' [ED. *W.I.B.*]

Until the planters in the West Indies recognize the great importance to the industry of careful seed selection, it will be impossible for the industry to make the advance it otherwise would.

Before closing my paper I should like to say a few words touching the loss the cotton industry in Barbados is sustaining through the departure from the island of Mr. Thornton. This gentleman, who has decided to withdraw from the Imperial Department to grow cotton for himself in the island of Tobago, has for the last three years been assisting the planters in Barbados and in the other colonies with the cotton industry, and it is with much pleasure that I can bear testimony to the high appreciation in which his services are held by the planters in this island. From the beginning, he has endeavoured in every way possible to assist them and to advance their interests, and I am sure that I am only voicing their feeling when I say it is with much regret that they have learnt of his intended departure from the island.

APPENDIX.

The average results of plantation No. 1 in St. Philip are as follows:—

Area planted in cotton	110 acres.
Average quantity of seed-cotton per acre	498 lb.
„ „ „ lint per acre ...	140 „
„ „ „ seed .. „	345 „
„ net amount obtained for lint after cost of ginning, shipping, and the selling expenses in England are deducted	39c. per lb.

EXPENSES.

	$ c.
Average expenses for agricultural labour per acre	18·48
„ „ .. manure per acre ..	8·42
„ „ „ salaries „ „ ...	2·96
„ „ „ taxes and insurance per acre .	2·65
„ „ „ repairs, bags, Paris green, etc. ...	2·00
„ „ „ upkeep of stock, freight, etc. ...	4·24
„ „ „ miscellaneous, staff, etc.	4·38
„ „ „ ginning, baling, and shipping lint, and expenses in England	4·55
Total average cost per acre	$48·64

RECEIPTS.

	$	£	s.	d.
Amount realized for lint ...	$6,006·00 =	1,251	5	0
Value of seed, 16·94 tons @ £5 per ton	406·56 =	84	14	0
	$6,412·56 =	1,335	19	0
Less expenses	5,350·40 =	1,114	13	4
Amount cleared on 110 acres	$1,062·16 =	221	5	8
Average clearance per acre	9·66 =	2	0	3

The average results of plantation No. 2 in St. Philip are as follows:—

Area planted in cotton	46 acres.
Average quantity of seed-cotton per acre	477 lb.
,, ,, ,, lint per acre ...	133 ,,
,, ,, ,, seed ,, ,, ...	338 ,,
,, net amount obtainable for lint after cost of ginning, shipping, and the selling expenses in England are deducted	39c. per lb.

EXPENSES.

	$ c.
Average expenses for agricultural labour per acre	13·83
,, ,, ,, manure per acre ..	8·09
,, ,, ,, salaries ,, ,, ...	2·64
,, ,, ,, taxes and insurance per acre ...	1·85
,, ,, ,, repairs, bags, Paris green, etc.	5·20
,, ,, ,, upkeep of stock, freight, etc. ...	5.26
,, ,, ,, ginning, baling, and shipping lint, and expenses in England...	4·32
Total average cost per acre	$41·19

RECEIPTS.

	$	£	s.	d.
Amount realized for lint ...	$2,386·02 =	497	1	9
Value of seed, 6·94 tons @ £5 per ton	166 56 =	34	14	0
	$2,552·58 =	531	15	9
Less expenses	1,894·74 =	394	14	9
Amount cleared on 46 acres ...	$ 657·84 =	137	1	0
Average clearance per acre ...	14·30	2	19	7

The average results of plantation No. 3 in Christ Church are as follows:—

Area planted in cotton	30 acres.
Average quantity of seed-cotton per acre	391 lb.
" " " lint per acre ..	112 "
" " " seed " " ...	274 "
" net amount obtained for lint after cost of ginning, shipping, and the selling expenses in England are deducted	39·8c. per lb.

EXPENSES.

	$ c.
Average expenses for agricultural labour per acre	14·26
" " " manure per acre ...	7·50
" " " salaries " " ..	4·42
" " " taxes and insurance per acre	1·75
" " " repairs, bags, Paris green, etc.	1·81
" " " upkeep of stock, freight, etc. ..	1·39
" " " miscellaneous . . .	1·44
" " " ginning, baling, and shipping lint, and expenses in England...	3·64
Total average cost per acre ...	$36·21

RECEIPTS.

		£	s.	d.
Amount realized for lint ...	$1,337·28 =	278	12	0
Value of seed, 3·67 tons @ £5 per ton	88·08 =	18	7	0
	$1,425·36 =	296	19	0
Less expenses	1,086·30 =	226	6	3
Amount cleared on 30 acres ...	$ 339·06 =	70	12	9
Average clearance per acre	11·30 =	2	7	1

The average results of plantation No. 4 in St. Philip are as follows:—

Area planted in cotton	100 acres.
Average quantity of seed-cotton per acre	548·76 lb.
" " " lint per acre ...	151·36 "
" " " seed " "	378 69 "
" amount obtained for lint after cost of ginning, shipping, and the selling expenses in England are deducted	39·4c. per lb.

EXPENSES.

	$ c.
Average expenses for agricultural labour per acre	12·31
" " " manure per acre ...	2·60
" " " salaries " " ...	3·43
" " " taxes and insurance per acre	1·36
" " " repairs, bags, Paris green, etc. ...	4·63
" " " upkeep of stock, freight etc. ...	2·12
" " " miscellaneous, staff etc.	·85
" " " ginning, baling, and shipping lint, and expenses in England	1·87
Total average cost per acre	$29·17

RECEIPTS.

		£	s.	d.
Amount realized for lint ...	$6,096·40 =	1,270	1	8
Value of seed, 16·9 tons @ £5 per ton	405·60 =	84	10	0
	$6,702·00 =	1,354	11	8
Less expenses	2,917·79 =	607	17	5½
Amount cleared on 100 acres	$3,584·21 =	746	14	2½
Average clearance per acre	35·84 =	7	9	4

DISCUSSION.

The PRESIDENT was glad to find that the prospects for cotton growing in Barbados this year were more favourable than they were last year. With regard to what Mr. Bovell had said about Mr. Thornton's services, he wished also to mention that as Travelling Inspector in connexion with cotton cultivation, Mr. Thornton's had been placed at the disposal of the planters of the West Indies through the generosity of the British Cotton-growing Association. He had been engaged with the work now for three years. During the whole of that time, he had found Mr. Thornton a very zealous and earnest officer, and he left the Department with its greatest regret. He trusted that in his own efforts in another part of the West Indies, Mr. Thornton would be successful, and would be the means of affording a large amount of assistance and encouragement to the cotton growers of Tobago.

THE COTTON INDUSTRY IN THE LEEWARD ISLANDS.

BY FRANCIS WATTS, C.M.G., D.Sc., F.I.C., F.C.S.,

Government Chemist and Superintendent of Agriculture for the Leeward Islands.

The growth and development of the cotton industry in the Leeward Islands from its beginning on experimental lines in 1900 to the end of 1906 have been described in previous papers in the *West Indian Bulletin* (Vol. VII, p. 30, and Vol. VIII, p. 179). In the present paper the information is brought up to date by the inclusion of the data for the past year.

The exports of cotton from the various islands of the colony are given in the following table, and for the sake of comparison, the corresponding figures for the previous two crop years (October 1 to September 30) are also included:—

TABLE I.

Island.	Pounds lint 1904-5.	Pounds lint 1905-6.	Pounds lint 1906-7.
Antigua including Barbuda	54,289	99,948	189,318
St. Kitt's	78,219	120,379	180,917
Nevis	144,721	120,168	96,402
Anguilla	31,452	80,650	61,666
Montserrat	70,723	98,262	164,430
Virgin Islands ..	4,100	6,975	10,177
Total, Leeward Islands	383,477	526,382	702,910

The year 1907 has proved itself to be a further period of steady progress in the industry, and marked increases are shown in the quantity of cotton produced. The total exports for the year amount to 702,910 ℔., valued approximately at £60,000—an increase of 35 per cent. in yield over the previous crop. As a result of the high market prices prevailing during the past season, very remunerative returns were obtained in the majority of cases. It is probable that the crop now being picked will show a still further increase. At the same time, however, it is not anticipated that future years will witness annual increases of such magnitude as have taken place in the past.

At the present time it is estimated that there are approximately 10,000 acres under cotton cultivation in the Leeward Islands. This is about half the total area under cultivation in sugar, and from this figure it is reasonable to suppose that the acreage will not increase very greatly for some time. During the next few years increases in yield are to be expected from improvements in cultivation rather than from greatly increased areas.

Further increases in area may be expected, but it is to be hoped that these will take place by reason of the gradual opening up of derelict and uncultivated lands, rather than at the expense of lands already under cultivation in sugar.

The returns of lint exported from the various islands show very substantial increases on those of the previous year; with the exception of Nevis, where bad season and prevalence of disease caused the output to be lower than that of either of the two previous years, and Anguilla where a lower yield than that of the previous year has also to be recorded.

The condition of the industry in each of the presidencies of the colony is reviewed in what follows.

ANTIGUA.

In Antigua the season of 1906-7 may be said to have marked a period of steady advance in the cotton industry.

The total export of cotton for the crop year amounted to 189,318 ℔. The average yield of lint for the crop per acre was, on the other hand, distinctly lower than the year before—a result attributable, in many cases, to the exceedingly unpropitious conditions as regards season.

The character of the lint produced has continued excellent, and uniformly high prices have been obtained, reaching as high as 29*d.* in some cases, and averaging 20*d.* to 21*d.* for the entire crop.

The growing season of 1907-8 has again witnessed a further marked increase in the area established in cotton in the island. At the present time there are 2,508 acres under cotton in Antigua, not including the dependency of Barbuda where there are 150 acres established in the crop, making a total of 2,658 acres for the presidency.

Speaking generally, the season may be said to have been moderately propitious, more particularly in the southern than in the windward cotton-growing districts.

Insect pests have not, on the whole, been as pronounced as in the preceding year.

Attacks of the cotton worm have, on the whole, been less felt and have been kept well in check. Some damage has been recorded from the attacks of the boll worm both in Antigua and Barbuda. The first recorded instance of this pest attacking cotton in the West Indies occurred in this presidency during the preceding season (*West Indian Bulletin*, Vol. VIII, p. 180, and *Agricultural News*, Vol. VI, p. 362). Some damage has also been sustained from aphis in some districts of

the island. Leaf-blister mite has again been in evidence, but its ravages have, on the whole, been better held in check in this season than has been the case in previous years.

In October and in the earlier part of November some anxiety was occasioned by the occurrence of a blight in the windward district which caused the leaves of the plants to wither and drop. This occurred after the heavy rains of September, and, it is thought, may have been due to the partial water-logging of the limestone soils of this part of the island. The advent of drier weather witnessed, in the majority of cases, amelioration of the conditions.

Some trouble has also been experienced from the shedding of bolls by the plants: in some cases this trouble reached an acute stage. Frequently the shedding of the earlier crop of bolls has been followed by the setting of a promising second crop.

Recently, a dropping of flower buds has been reported, and will require investigation.

On the whole, the prospects for the yield for the coming crop would appear to be fair.

The whole of the area under cotton during the present season has been planted with seed raised in the island, and selected by the Antigua Cotton Factory Company under the supervision of the Agricultural Department. Considerable quantities of locally raised seed have also been exported to the neighbouring islands of St. Kitt's, Nevis, and Montserrat.

An important innovation during the past season has been the application of implemental tillage to cotton cultivation in Antigua, several planters having imported implements for use in this respect. It is as yet too soon after their introduction to be able to form a reliable opinion as to the value of the results likely to accrue from their use.

During the present season, manurial experiments with cotton are being conducted, by the Agricultural Department, on two estates, in co-operation with the management, on the same lines as pursued heretofore. Extensive experiments in cotton selection are also being carried out by the Agricultural Department, in co-operation with planters, at various points.

During the past year, the ginnery, formerly owned by the Government and worked by the Agricultural Department, was successfully worked by the locally constituted company to whom it had been transferred at the end of 1906. At the time of the transfer two new gins were added to the equipment by the company, and at the present time further additions of an additional 9 horse-power oil engine, two new gins and some minor improvements in tramway conveyors for cotton seed, etc. are being made. The equipment of this ginnery, when these additions have been made, will consist of two 9 horse-power oil engines, six single-action Macarthy gins, a Christy and Norris disintegrator, together with shafting, conveyors, etc. The additional oil engine will enable the six gins and the

disintegrator to be run simultaneously, which was not possible under the former conditions.

In addition, two new ginneries have been erected and worked in Antigua during the past year, one at Colebrook in the Windward district of the island, the other in St. John's.

A small ginnery equipped with an oil engine has also been successfully erected and worked by the Government in the neighbouring dependency of Barbuda.

ST. KITT'S-NEVIS AND ANGUILLA.

Considerable progress has been made in the industry during the past year. In St. Kitt's, the yield of lint per acre on estates for the season 1906-7 was, generally speaking, good, and the high prices obtained made it very remunerative.

In Nevis, from climatic and adverse weather conditions, the return of lint per acre was small and much below the average for previous years. This has been a cause of great discouragement to cotton growers.

In Anguilla the return per acre was also low, but the total results, together with the good prices obtained, meant a decided advance to this small island, which four years ago exported nothing of value, while in this season the value of the lint and seed exported was approximately £6,000.

The high prices of this and last season induced the planters in St. Kitt's to plant a larger area in cotton, and for the season 1907-8, 2,000 acres were put in, 1,500 as an intermediate crop with cane and 500 as a main or rotation crop.

The greater part of this was planted in June and July, and though the earlier plantings suffered to some extent from want of rain, yet, since the rains of October, the trees have recovered and a very good return per acre is expected. The report on the first shipments has been good, the cotton being valued at 23*d*. to 24*d*. per ℔.

The attacks of the cotton worm have been fewer and less serious than in previous years, and no damage has been done by them in St. Kitt's. The leaf-blister mite has been troublesome since the rains of October, the new growth and the young buds being attacked. Dusting with sulphur and lime at this stage is of little use : the only means of keeping it under is by pruning and picking off the diseased leaves.

A leaf disease gave some trouble in one particular district at the end of the drought, but since the rains there has been no recurrence of it. It would appear that there would be little danger from this in good seasons.

The ginneries are the same as in last season. An oil engine has been erected at Stone Fort to take the place of the aermoter. At Spooners,' a considerable advance has been made in the putting up of an oil extraction plant, in connexion with the ginnery, by Messrs. Sendall and Wade. At present the equipment does not include plant for refining the crude oil, but the addition of such plant is in contemplation.

The condition of the industry in St. Kitt's is most encouraging, and the fact that the cotton is grown almost

entirely as an intermediate crop with cane, renders it all the more remunerative and useful to the island. Up to the present—and it is now four years since cotton was first grown in this way in St. Kitt's it has not been found to be in any way harmful to the next crop of canes, and with careful manuring there seems little risk in continuing this system of planting.

Cotton manurial experiments have been continued on the experiment plots at La Guerite on the same lines as during the past three seasons.

Cotton selection experiments have this year (1907) been inaugurated in St. Kitt's on the lines followed by the Imperial Department of Agriculture in Barbados, St. Vincent, and Antigua; the experiments were carried out at La Guerite and on Conaree estate. It is hoped that valuable results may be the outcome of these experiments.

A considerable area has this year again been established in cotton in Nevis, notwithstanding the discouraging results of last season's crop. It is estimated that at the present time there are 1,800 acres under the crop in the island.

Owing to the peculiar conditions existing in Nevis, and the number of small growers, it was found necessary, at the end of 1906, to send a temporary Cotton Instructor to assist these small growers.

In April 1907, an Agricultural Instructor was appointed to give his whole time to the work, and this seems to have succeeded in placing the smaller growers in possession of information which has resulted in a more intelligent treatment of the crop. At the present time, although complaints are heard in some districts, the conditions, on the whole, are very much improved, and the prospects of a better crop being reaped are hopeful. Recent reports fully support this conclusion.

The cotton worm has been active in Nevis, and has been kept in check with some difficulty. Leaf-blister mite has also given some trouble in its control.

The erection of a large factory in Nevis, by a company operating under the title of 'Nevis Limited,' has been a striking advance during the year. The equipment includes ginning and baling (hydraulic) plant, together with an oil extracting and refining plant. The introduction of this capital and enterprise ought to have a beneficial effect on the industry. The other ginneries at Stony Grove in Charlestown have continued operations on the same lines as heretofore.

As cane cultivation has been practically abandoned in Nevis, at any rate on the larger estates, cotton has become almost the only industry in the island, and if the present season should prove more favourable than the last, there is every prospect of a much larger area being established in the crop in the near future.

Anguilla is estimated to have some 1,500 acres under cotton. The return of lint per acre there obtained never seems to be as high as in other places, but the cost of cultivation is so low, since much of the actual labour is performed by the

owner or renter of the land, that the actual receipts are very satisfactory to the small grower, who has never before planted a crop which has given such good results.

The chief ginnery is owned by Mr. C. Rey, who makes advances to small growers and also purchases their cotton at rates determined by the current market price. Mr. Rey has himself been assisted by the Government and the British Cotton-growing Association with advances, in order to enable him to undertake these operations, which are of very great benefit to the small growers.

The prospects for this season's crop are spoken of by Mr. Rey as very encouraging. The importance of this point can only be fully realized when it is remembered that four years ago, as already stated, there were no exports of value from Anguilla.

MONTSERRAT.

Probably in no island in the Leeward Islands, with the exception of Anguilla. has the cultivation of Sea Island cotton been productive of better results than in Montserrat. At the present time its cultivation ranks as the principal industry, and in the year under review the exports of the staple amounted to 104,340 lb., valued at £12,189. This is equivalent to an average yield per acre of 156 lb. of lint, and the total export shows an increase of 66,168 lb. over that of the previous season. The actual prices realized for the crop varied from 1*s*. 6*d*. to 2*s*. 1¾*d*. per lb. It is, moreover, gratifying to note that the lint produced, manifested a marked improvement in quality over that of the earlier crops.

For the present crop it is estimated that 2,002 acres have been under cultivation, as against 1,050 for 1906-7. Of this about 200 acres consist of land newly cleared from forest. This marks the inauguration of the re-opening up of some of the long-abandoned lands in the north-eastern part of the island.

Peasant proprietors are responsible for the cultivation of a total area amounting to 400 acres. Practically the whole of this area has received an amount of care and attention from the cultivators that is praiseworthy in the extreme, and the cotton that is likely to be produced thereby represents a sum of between £3,000 and £4,000.

The growing season has, on the whole, been favourable. The greater part of the crop was planted in July and August; the outlook was not altogether propitious until a good rainfall in September effected a material improvement in conditions. Since then, the weather has been distinctly favourable.

The pest that has given the most trouble has been the cotton worm. In a few cases, serious damage has been done by it, but in the majority of instances it has been well kept in check by the application of arsenical insecticides. During the year, several tons of London purple were used as a substitute for Paris green in the control of the worm, with satisfactory results.

Experience in the past season has shown that there is little to fear from the leaf-blister mite so long as all old plants are destroyed some time before the new crop is planted.

Picking commenced in October and is by now probably half completed. The actual shipments of lint already made (January 1908) amount to 100,000 lb., and there is every promise of at least as good an average return per acre as last year.

During the past season two additional ginneries have been erected in the island, one in Plymouth, the motive power for which is supplied by an oil engine, and the other at Blakes, which is driven by steam.

VIRGIN ISLANDS.

The cotton industry in the Virgin Islands is entirely carried on by peasants and small cultivators; its growth dates from 1904.

In order to aid in the development of the industry, it is the practice of the government to purchase seed-cotton from the growers at rates governed by the current market prices.

The seed-cotton is then ginned and shipped, and the proceeds are credited to the government.

This procedure has been adopted, as it would be difficult, if not impossible, to interest the peasants in the crop, were it necessary for them to wait till the proceeds of the sale could be remitted to them from England.

Under this system the industry has developed rapidly. During the last season 39,750 lb of seed-cotton were purchased from peasant growers, who received £332 18*s*. 4*d*. for it, and 10,120 lb. of clean lint were shipped.

It should be stated that only about one-third of this was Sea Island cotton, the remainder consisting of the native variety. Efforts are being made to induce the cultivators to abandon the growth of the native variety of cotton in favour of Sea Island. So far, success has been obtained, but there are, however, a few districts in some of the outlying islands where it would seem advisable to continue the growth of the native variety.

A ginnery, containing a gin worked by an aermotor and a baling press, was erected by the government in 1904, and up to the present time this has successfully ginned all the cotton produced in the presidency.

At the time of writing, various improvements are being made in the ginnery, and an oil engine is being substituted for the aermotor as a source of power, while the buildings are being substantially enlarged.

There appears to be good reason for hoping that the development of the cotton industry in this presidency may be as productive of beneficial results as it has proved to be in Anguilla and Montserrat.

RECENT RESULTS OF THE CULTIVATION OF SEA ISLAND COTTON AT ST. VINCENT.

BY W. N. SANDS,

Agricultural Superintendent, St. Vincent.

At the commencement of this paper it should perhaps be stated that, possibly, in no other small island of the West Indies where the Sea Island cotton industry has been established, has it proved a greater boon than in St. Vincent.

The island was visited by a severe hurricane in 1898, and disastrous eruptions of the Soufrière occurred in 1902-3. These disasters, together with unremunerative prices for the staple products, arrowroot and sugar, reduced the island to a very unfortunate position.

In 1903, the cultivation of Sea Island cotton was introduced by the Imperial Department of Agriculture, and to-day notwithstanding the comparatively recent dates of the disasters above mentioned, the island is in a fairly prosperous condition. A few of the indications of this satisfactory state of affairs, brought about in no small measure by the establishment of the Sea Island cotton industry, are the following: the revenue of the colony is exceeding the expenditure; exports and imports are rising rapidly; estates are in full cultivation; and there is full employment for the peasant and labouring classes.

RECENT EXPORT RETURNS OF SEA ISLAND COTTON.

Year.	Exported.	Value.
	Pounds.	£.
1905-6 ...	121,174	6,059
1906-7 ...	225,635	16,922

The quantity of Sea Island cotton ginned each season, that is, from October to May, shows a still better record.

Year.	Acreage planted.	Pounds of lint ginned.
1905-6	790	121,174
1906-7	1,530	253,704

The estimated value of the 1906-7 crop, based on prices realized, that is, white cotton at 27*d.* per lb. and stained at 9*d.*,

amounts to £25,568, which with the estimated value of the seed, £1,530, makes the total value £27,093.

This season, 3,200 acres have been planted, as against 1,530 last year, and owing to a favourable season and good prices, it is estimated that the value of the crop should amount to £45,000.

The great value and importance of the industry can thus be readily seen from these figures.

The chief areas are planted in June, July, and the beginning of August As a rule, the July plantings have given the best results. All of the seed before planting is carefully selected, disinfected, and tested, and only that from the cotton realizing the highest market price is sown each season. With the exception of the last, the whole of the selection work has been done by the Agricultural Department. Last season, owing to the unusual demand, the large growers dealt with their own seed for planting, and the Department confined its efforts to supplying the small growers.

As mentioned in a previous paper published in the *West Indian Bulletin* (Vol. VIII, pp. 183-6), the rainfall of the island is very heavy, and ranges from 80 to 120 inches per annum in the cotton districts. The soil generally is very light, and this rainfall does not prevent satisfactory crops being obtained in average seasons.

In the St. Vincent Grenadines, however, the rainfall is much less, ranging probably from 35 to 45 inches. In these small islands, nearly all of which are now growing Sea Island cotton, considerable progress has recently been made, and, although the cotton is not equal in fineness to that produced at St. Vincent, very satisfactory returns are being obtained.

A short-stapled variety known as 'Marie Galante' or Union Island cotton, has been grown for a number of years in the Grenadines. This cotton, however, gives a poor yield, and sells at a low figure. Under these circumstances, it is hoped that the Sea Island variety will, in the near future, replace to a large extent this inferior type.

From results obtained last season in dealing with a large quantity of both varieties at the Central Cotton Ginnery, the percentage weight of lint to seed-cotton of the 'Marie Galante' variety was 24·7, as against 27·9 for the Sea Island. This is an important point worthy of consideration.

The average yield of Sea Island lint per acre, during the past two seasons has been 174 lb., and 175 lb. respectively. In very favourable districts the yield has been much heavier, and returns up to 360 lb. per acre have been recorded, but these are counterbalanced by lower returns from other places.

It should be mentioned that, as a rule, only first pickings are obtainable, and it has not yet been possible to get second pickings to any extent, owing to the attacks of the leaf-blister mite and other diseases.

The high quality of the St. Vincent lint has often been referred to, and each season the highest market prices of cotton from the West Indies have been obtained for it.

From reports to hand it appears that the points in which cotton grown here excels, are—a low percentage of weak fibres, lustre, and fineness.

The cotton worm (*Alabama* [Aletia] *argillacea*) has not yet proved a serious pest, and its natural enemies, such as the Jack Spaniard, a large predaceous beetle, and parasites, appear to have kept it in check. It is, however, well distributed and might at any time multiply so rapidly as to do great damage, unless planters have a full supply of insecticides ready at hand, to deal with it.

EXPERIMENTS.

After consultation with the scientific officers of the Imperial Department of Agriculture, various experiments have been commenced in order to keep up the quality of the cotton. Plant-selection experiments were started last season on several estates in different districts of the island, on similar lines to those being carried out in other West India Islands. The seed from the selected plants which produced lint of the highest quality has been sown in specially prepared nurseries this season, and the work will be carried on from year to year.

At the experiment station attached to the Agricultural School, a series of experiments, on the recommendation of the Mycologist attached to the staff of the Imperial Department of Agriculture, has been commenced with a view to ascertaining the best means of control of fungus diseases. The experiments now in progress include wider planting, larger applications of phosphates and potash, and the use of fungicides.

CONCLUSION.

In conclusion, I would call your attention to certain samples of cotton now presented for examination; especially would I refer to those from Mustique, Carib Country, and from two estates in St. Vincent.

The sample from Mustique shows the character of the cotton produced in the Grenadines. Although it is a little coarse, it is nevertheless of very good quality. The sample from the Carib Country is of interest as showing the class of cotton now being produced, through the enterprise of the proprietors, in the volcanic ash of the recent eruptions of the Soufrière. This also is of very good quality. I might mention that from 100 acres planted in the district the owners are hopeful of obtaining from 30 to 40 bales of 360 ℔. each.

The samples from two St. Vincent estates are types of the finest cotton produced at St. Vincent.

DISCUSSION.

The PRESIDENT remarked that he was greatly interested in the story given by Mr Sands, especially as that gentleman had taken so active a part in developing the industry in St. Vincent. In order to assist the planters at the

commencement of the industry, the Imperial Department of Agriculture undertook to lay out a dozen experiment plots, to pay the whole cost of cultivation, to gin, bale, and sell the cotton, and to hand over the proceeds to the planters, on condition that they followed the recommendations of the Department as to the methods of cultivation. The following year the planters took up the industry themselves and had developed it on such successful lines, that the name of St. Vincent cotton was getting known everywhere. The planters, he thought, were to be congratulated on the success of the industry.

Hon. J. G. W. HAZELL (St. Vincent) said that -before the introduction of cotton cultivation St. Vincent was in a very poor way – planters were on their last legs. Sir Daniel Morris came to the rescue, experiment cotton plots were started, the planters readily carried on the cultivation on the lines indicated by the Department, and they were now reaping their reward. Last year they got top price in the market for their cotton. Encouraged by their success they had extended the industry to the Grenadines, especially in Mustique, where stock breeding was at present the principal industry, but where for a number of years and up to the time of the American war short-staple cotton was cultivated. They had succeeded in inducing the labourers there to go in for the cultivation of Sea Island cotton. The area under cultivation was gradually extending and the industry was proving a boon to the people.

COTTON CULTIVATION IN BRITISH GUIANA.

BY PROFESSOR J. B. HARRISON, C.M.G., M.A., F.I.C., F.C.S., F.G.S., F.G.S.A.,

Director of Science and Agriculture, British Guiana.

Practically all the numerous experiments made in British Guiana since 1902 with regard to the cultivation of Sea Island cotton have been more or less complete failures owing to the unsuitability of the heavy soil and of the meteorological conditions existent on the sea-board of the colony. The season 1907-8 has been for cotton growing the most favourable one experienced since the trials have been started. The yield of Sea Island cotton at the experimental fields, however, was only at the rate of 268 lb. per acre of seed-cotton, the lint from which was valued at 18*d.* per lb.

Acting on the advice of the Imperial Commissioner of Agriculture, who in 1903 recognized the fact that Sea Island cotton was not likely to grow so successfully in British Guiana as it does in certain of the West India Islands, we have experimented with other varieties. Some of our results in the Experimental Field this year with them were as follows:-

Variety.	Pounds of seed-cotton per acre.
Egyptian Yannovitch	378
Buck cotton (an indigenous variety) ...	450
Caravonica kidney cotton	385
Caravonica wool cotton...	519
Caravonica silk cotton	1,404

The lint from the Buck cotton was recently valued at 9*d.* per lb., that of the Caravonica silk cotton at 9½*d.*

We have also tried seed selections of Egyptian cottons. Egyptian cottons gave us a mean yield of 227 lb. of seed-cotton per acre. Metafifi cotton grown from the first seed selection produced 310 lb., whilst Metafifi of the second selection resulted in 546 lb. The lint from the original Metafifi was valued at 7½*d.* per lb., whilst that yielded by the plants of the second selection was valued at 9½*d.* per lb. These experiments show that there is much promise in this line of work so far as raising vigorous strains of Egyptian cotton that will flourish on the heavy clay lands of the colony is concerned. But whether such

a strain will yield lint in quantity sufficient to enable it to be grown at a profit, in face of the very expensive kind of cultivation we have found it necessary to adopt in order to get crops of any promise, remains to be settled by trials on a large scale. Unfortunately, with the exception of the Buck cotton, all of the varieties hitherto tried have been found very subject to the various diseases prevalent among cotton plants in this colony, more especially to anthracnose, and to cotton boll rot.

Our efforts have also been directed with some success to attaining hybrids of Sea Island cotton with the Buck cotton. We have about 120 hybrid plants under experimental cultivation.

DISCUSSION.

The PRESIDENT inquired whether any one in the room had had any experience with Caravonica cotton.

Mr. A. D. C. ADAMSON (St. Kitt's) stated that he had tried the Caravonica cotton at St. Kitt's. The area was 1½ acres: he had been picking since March last and had got 1,200 ℔. of seed-cotton at one picking and 1,060 ℔. at another. There was a very large proportion of stained cotton as the result of planting the trees too close. He had shipped a small bale of lint which sold at 10*d*. per ℔.

Hon. W. FAWCETT (Jamaica) said they had tried Caravonica cotton here and there in Jamaica, and their experience had been that of the last speaker. He had grown some at Hope Gardens and it sold at 10*d*. a ℔. Then it was tried by Mr. Barclay the Secretary of the Agricultural Society in the centre of the island and Mr. Barclay had informed them that it had produced cotton for every month throughout the year; and it seemed better suited for peasant cultivators than the Sea Island cotton. It did not seem to be subject to pests. But they kept in mind the warning that had been given by the President and the cotton spinners, that hybridization might take place, and therefore they tried to discourage the cultivation of the Caravonica cotton.

Mr. J. H. HART (Trinidad) stated that there should be about 60 acres of Sea Island cotton in Tobago. In Trinidad, the only variety of cotton that had been anything like satisfactory was the 'Sunflower' cotton, a superior grade of Upland cotton.

PROGRESS OF THE SEA ISLAND COTTON INDUSTRY IN THE WEST INDIES.

BY THOMAS THORNTON, A.R.C.S

Travelling Inspector in connexion with Cotton Investigations, attached to the Imperial Department of Agriculture for the West Indies.

The history of the Sea Island cotton industry in the West Indies is of very great interest because of the rapid progress that it has made. The improvement in the methods of cultivation that have been adopted as the acreage extended, has also been most marked.

In six years cotton has grown to become a very important industry in many of the West India Islands, and has been the means of considerably improving the financial position of many of these colonies.

Cotton was first planted on a commercial scale in the year 1902, when about 400 acres were put into cultivation. In 1903, this area was extended to 4,000 acres; in 1904 to 7,000 acres; in 1905 to 9,500; in 1906 to 14,500; and for the season 1907-8, 20,000 acres are under culture in this crop.

There has been a general improvement in the quality of the lint produced, for the plants have become acclimatized, and at the same time the methods of cultivation and of preparing the product have received careful consideration. At the present time, the West Indies can successfully compete with any country in the world in the production of Sea Island cotton and, in some instances, exceptionally fine samples have been produced.

When cotton was re-introduced into the West Indies, it was a new crop to all concerned. Managers of estates had to commence at the beginning, and labourers had to be trained. It had to be determined what methods of cultivation were likely to be the most successful, and many experiments had to be given careful trial. To-day we have sufficient data available to be able to indicate, in general, what methods are likely to lead to successful cultivation There are, however, several points in connexion with cotton cultivation that have not yet been satisfactorily settled, and therefore, we must continue with experiments for some time to come.

The following points have become established and are adopted by our best cotton planters:—

(1) All cotton lands should be well prepared.

(2) The land should be left for some time to mellow or 'cool out' before planting is done.

(3) That it is most important that cotton lands be well drained.

DISTANCES OF PLANTING.

As regards planting, great improvements have been made. Considerable attention is now given to the careful preparation

of the land, and to the distances at which the seed is planted. In the earlier years it was thought by many that the greater number of plants to the acre would produce the greater yields, but now it has been fairly generally established that it is best to plant in single, straight rows, and where cotton is a rotation crop with canes, with the rows from 5 to 6 feet apart. The seeds, usually about four, are then planted at distances of from 18 to 20 inches apart in the rows.

Machines for planting purposes have been imported into Barbados and Antigua. At Dodds, Barbados, a machine has done very satisfactory work, and several planters have similar ones on order. The machine is drawn by a mule and can be regulated to drop any number of seeds at distances required. It opens the ground, drops the necessary number of seeds, and covers them over, and, if required, it can be arranged to drop artificial manures at the same time as the seed. It is estimated that about 6 acres per day can be planted by one of these machines.

SHEDDING OF COTTON BOLLS.

In some quarters, the falling off of large numbers of young buds and bolls has been experienced. As many as half the bolls that should mature under normal conditions have, in some fields, been shed from the plants.

A bad attack of aphides during the time that the plants are rapidly forming flowers and bolls will cause many of them to be shed, and it has recently been brought to notice at Antigua that young flower buds which are being shed contain the maggot of a small fly. It has not, however, been generally experienced that the general shedding of bolls is due to insect pests or to fungus diseases, for it has been observed that the following causes may result in an abnormal amount of this shedding taking place :—

(1) Root pruning by deep cultivation.

(2) Surface of soil becoming hard and caked, or becoming covered with weeds.

(3) Excessive vegetative growth during the flowering period.

(4) Very heavy rains.

(5) Severe drought.

(6) Exposed position of the plants.

(7) Overcrowding of the plants.

It would appear, therefore, that the shedding of bolls is due to an abnormal physiological condition inside the plant and that the question of moisture plays a considerable part in causing it to take place. To combat it, conservation of soil moisture and careful drainage should receive every consideration. It is very probable that constant stirring of the surface soil and good drainage will do much towards assisting the plants to mature the maximum number of bolls. In this connexion, the use of mule-drawn cultivators is likely to be of great service. They are extensively used for cotton in the United States of America, and have given great

satisfaction in the cotton fields at St. Croix. They are at present being given a trial at Antigua, and it is possible that they will be experimented with in other islands.

PICKING AND SORTING OF COTTON.

In the picking and sorting of cotton, each year sees the work done more thoroughly. The spinners appear to be very satisfied with the manner in which the work is carried out. On some estates it has reached a high standard of efficiency, and there are now very few complaints of badly picked and prepared cotton being sent the spinners from the West India Islands.

QUALITY OF THE COTTON.

There are natural limits which serve to determine more or less the quality of the cotton produced. The rainfall and the character of the soil are perhaps the most important factors.

Cotton grown in the driest districts is short and of a coarse nature. That obtained from localities where the rainfall is greater is generally both longer and finer.

When the soil is of a heavy character and retentive of moisture, the cotton produced has a tendency to become very weak and wasty, particularly if the rainfall is high. If, however, the soil is fairly light in character and very porous, the quality of the cotton does not appear to suffer. In St. Vincent, where the soil is sandy and very porous, the cotton is very strong, even though the rainfall is very heavy for cotton localities. In fact, no stronger cotton is produced in the West Indies than that of St. Vincent.

QUALITY OF VARIOUS PICKINGS.

In most of the islands, owing to the presence of the leaf-blister mite, it is impossible to obtain more than one picking, but in Barbados, where this pest has not made its appearance, two, and sometimes even three pickings have been obtained. The advisability of keeping plants to produce a third picking has occasionally led to important discussions. This last season there has been an opportunity to examine a number of cotton samples taken from individual plants from the first, second and third pickings, and it has been found that in each instance the best cotton is obtained from the first picking. The length of the cotton is greatest at the first picking. It decreases at each subsequent picking. At the second picking there is less weak fibre present, but at the third, the weak fibre may be present to a very abnormal extent. The second picking is rather coarse and brittle, and the third is too soft and as the spinner says, is lacking in 'bone.'

It is probable that the coarse and brittle nature of the second picking is due to the dry season in which it is grown, and the soft nature of the third picking to the degenerate character of the plant, due to age.

It should be borne in mind that the spinner does not want weak and wasty cotton, and when an island commences to supply it, spinners who buy are apt to look with suspicion on

the cotton produced in that island. Irrespective of the trouble brought about by diseases, the quality of cotton they are likely to produce, should influence the planter when deciding whether he shall grow third picking cotton or not.

SEED SUPPLY.

The question of the supply of seed for planting has been given careful consideration throughout all the islands.

In 1902, arrangements were made by the Imperial Department of Agriculture for a supply of Sea Island cotton seed through the United States Department of Agriculture. This was distributed for the planting of 1903.

Towards the end of 1903, arrangements were made by the Imperial Commissioner of Agriculture, when he and Mr. Bovell were visiting the Sea Island cotton-growing districts of America, for a large supply of the best Rivers' and Seabrook strains of seed. This was used for the 1904 planting throughout all the islands.

For the 1905 crop, arrangements were being entered upon for a further supply from the Sea Islands, when information was received that the planters there were resolved not to sell their seed to 'communities outside South Carolina.' It was at first thought by West Indian planters that this was a hardship, but it has subsequently been demonstrated that it has really been advantageous to these islands, for the question of seed supply had to be very carefully considered and thorough selection practised. It was realized that some estates produced better results than others both as regards yields and the quality of the lint. The seed produced on these estates was therefore purchased. It was carefully hand picked, and all but the best developed seeds were discarded. In this way, the seed for the 1906 crop was furnished, and contrary to the expectations, and perhaps, the wishes, of the South Carolina planters, the quality of the crop reaped was greatly superior to that obtained from the seed imported for the previous season from the Sea Islands.

Since 1906, the seed for general planting purposes has been obtained in this manner.

SEED SELECTION.

From the beginning it was recognized that the above method of obtaining seed for planting purposes could be improved upon.

Plants grown from seed vary, to a greater or less extent, from one another. If there is any variation in the first generation, each succeeding generation, which is produced from parents with varying characters, will become more and more varied. It was necessary, therefore, in order to obtain a good, uniform quality of cotton, to adopt a system of seed selection in which certain individual plants, selected for their good qualities, are made the starting point each year.

In the first year after the supply of American seed was cut off, experiments in plant selection were commenced on seven estates in different localities of Barbados. In the next year

(1906-7), this work was extended to ten estates in Barbados, to five estates in St. Vincent, and to the experiment stations at Antigua, St. Kitt's, and Montserrat. This year the work is again being carried on throughout the different islands, and experiments have been commenced in the Virgin Islands.

The advisability of this careful selection work is now realized throughout all these colonies. The requirements of the spinner have to be considered and every effort made to produce that class of cotton that he desires.

One point which the spinner strongly emphasizes is that the cotton must be uniform. A careful examination of cotton on the plants in the field, shows that, although a large pecentage of the different plants are producing a fairly uniform quality, yet there are some that produce a better, and others an inferior. grade. When seeds are planted from an individual plant, a little variation will usually be found, but not nearly so much will be observed as when seed is taken from a general field crop.

Many plants also show a certain amount of resistance to disease, have a greater power to withstand adverse climatic conditions, are less liable to shedding of bolls, and they may produce a larger yield of longer, finer, and stronger cotton.

This principle of selection of individual cotton plants is already giving exceedingly promising results.

At one estate in Barbados, in 1905-6, three plants were selected as the most desirable types. Two of these appeared to be of a very promising nature. In 1906-7, they were propagated in a nursery, and sufficient seed was obtained from them to plant a considerable portion of the estate, and it is estimated that it will be possible from this crop to obtain more seed, directly descended from these three plants, than will be required to plant the total cotton area of Barbados.*

On another estate, situated in a district with conditions very different from that above mentioned, two plants were last season finally selected. The plants growing from the seed obtained from one of these appear to be exceptionally promising, and this strain will be tried on a commercial scale during the coming season.

By carrying out these experiments, varieties of plants, especially suited to local conditions of soil and climate will be obtained, and by making the best plant in the nursery, each year, a fresh starting point, a gradual improvement will take place. Instead of producing a crop with divergent characters, there will be, each year, a tendency for the quality of the lint to become more and more uniform. The proportion of weak fibre will be reduced, the length of staple and the proportion of lint to seed improved, and the general productiveness of the plant increased.

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* Seven bales of cotton directly descended from one of these originally selected plants (No. 303—see *West Indian Bulletin*, Vol. VII, p. 159) have been reported upon by cotton brokers as follows: 'It is the most serviceable class of cotton produced in the West Indies, and if it gives a better yield per acre than the finer descriptions—as it probably will—we think it is most suitable for extensive cultivation.'

EXPERIMENTS ON THE IMPROVEMENT OF COTTON BY SEED SELECTION IN THE LEEWARD ISLANDS.

BY FRANCIS WATTS, C.M.G., D.Sc., F.I.C., F.C.S.,
Government Chemist and Superintendent of Agriculture for the Leeward Islands,
and
H. A. TEMPANY, B.Sc., F.I.C., F.C.S.,
Assistant Government Chemist for the Leeward Islands.

The Sea Island cotton now largely cultivated in these islands is derived from seed obtained from the Sea Islands of the State of Carolina. The original type of cotton in the West Indies from which the Sea Island cotton has been evolved was presumably akin to the cotton now growing wild in these islands. This type is very inferior in quality, and is essentially different from cotton of the Sea Island type. This change has been brought about in the Sea Islands by the careful selection carried out by the cotton planters themselves, their work in this direction having been aided in later years by the United States Department of Agriculture.

Cultivating then, as we are, a plant so highly developed and somewhat unstable, there was danger lest it should gradually revert to the original type of West Indian cotton. It was essential, therefore, to the permanency of our industry, that rigorous selection should be carried on for the preservation of the highest quality. We may, however, accomplish more than this, for the variability of the plant leads to the expectation and the hope that by setting before ourselves well-considered standards, we may be able to produce improved types of cotton suitable alike to the conditions of our surroundings and our markets.

In the work of maintaining the quality of the cotton, the Imperial Department of Agriculture, after the importation of seed, has aided the planters by selecting good qualities in various islands and from various estates for distribution for general planting. The work of hand picking the seed to remove undesirable kinds has either been actually undertaken, or instruction as to how this work should be done has been given and the work supervised. This work should gradually devolve more and more upon the planters themselves, who should strive to the utmost to maintain the excellence possessed by any good type of seed entrusted to them for general planting. To this end it is essential that the planters should understand the general principles of selecting seed and carry on, year by year, well considered work in this direction. They should become competent to select and preserve types of cotton suited for particular conditions, and for particular markets.

The work of producing improved types of cotton will fall more especially upon the Department of Agriculture, for this requires careful laboratory and nursery work beyond the range of most estates. This field covers the ground of the production of new and improved types wherein particular features of length, strength, uniformity, lustre, and other qualities of fibre, or of particular characters of the plant, such as habit of growth, resistance to disease, and the like are developed.

In all this work there must be co-operation between the planters and the scientific workers of the Department of Agriculture, and progress will be largely dependent upon the thoroughness and efficiency of this co-operation.

Selection is best effected by performing the work upon cotton grown in the locality in which the main crop is to be grown. This gives great importance to the selections made on estates' crops, and to the co-operation of the planters and scientific officers.

In the selection experiments that have been carried out in Antigua, these facts have always been kept in view, as in similar experiments conducted by the Department elsewhere.

Selection experiments were first inaugurated in Antigua in 1905. In that year a number of cotton plants were selected by the Curator of the Botanic Station from the cotton plot at Skerrett's experiment station, and the lint produced by them was subsequently examined at the Government laboratory. In the same year a circular was issued by the Agricultural Department, drawing attention to the importance of selection in cotton cultivation, and indicating the best method of making the selection. All lint from selected plants would, it was stated, be examined, free of charge, at the Government laboratory.

This appeal was not very largely responded to, although selections were made on several estates and the lint submitted for examination at the laboratory. As a result, a few small areas were established on estates from the seed selected in this way.

In the growing season of 1906, a much more extensive series of selection experiments was laid down by the Department. These included, in addition to a series of experiments on the experiment station plot at Skerrett's, selection experiments on two estates representative of the conditions obtaining in the two important cotton-growing districts of the island, namely, the Southern and Windward districts. These estates were Blubber Valley in the Southern district, and Sion Hill in the Windward district. The co-operation of the management of these two estates in carrying out the experiments was invited by the Department.

In dealing with the experiments carried to completion during the two years under review, the results achieved and the methods adopted in the season 1905-6 will be first considered.*

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* See *Report* on Botanic Station, Experiment Plots, etc., 1905-6, p. 14.

A number of plants were selected from the experimental cotton plot at Skerrett's,—the selected plants being chosen for their field characteristics—strong vigorous growth, freedom from disease, and quantity of bolls.

The selected plants had been grown from St. Vincent Rivers' seed imported into Antigua by the Imperial Department of Agriculture. The seed-cotton from these plants was collected and forwarded to the Government laboratory for the examination of the lint. No attempt was made to keep separate the seed-cotton of each individual selected plant, the entire amount of seed-cotton obtained being bulked.

The examination at the laboratory was of the lint of individual seeds selected from the bulk of seed-cotton supplied. The chief characteristics on which the selection was based, were length, evenness, and strength.

The actual method employed in measuring the length of staple was that used by Mr. Thomas Thornton, Travelling Inspector in connexion with Cotton Investigations attached to the Imperial Department of Agriculture.

It is as follows:—

The seed with attached lint, which is to be examined, is held between the forefinger and thumb of the left hand: with the thumb and forefinger of the right hand the lint is smoothed away from the seed in such a manner that the attached lint is divided into two tufts standing out almost at right angles on opposite sides of the seed. The seed itself is then grasped between the finger and thumb of the left hand and the extreme ends of the smoothed fibre on one side are firmly grasped between the finger and thumb of the right hand; and with a steady pull the lint thus held is detached from the seed and transferred bodily to a board covered with some rough material such as baize, which, by reason of its roughness, will hold the detached lint in a position for measuring.

By this means the longest fibres of the lint are removed from the seed. The above operation is then repeated on the fibres remaining attached to the seed, after the removal of the longest, and so on until all the lint has been fractionally removed from one side and transferred to the baize-covered board, when the operation is repeated with the lint remaining attached to the other side.

The lint attached to a seed is thus divided into grades of gradually decreasing length; the grades are then carefully measured by means of a scale, and from the lengths of the various fractions or pulls, the average length of the fibres attached to a seed is estimated.

By evenness is meant the uniformity in length of the lint attached to the seed.

The strength was also taken account of in the determination in a general way, all samples which showed marked weakness being rejected.

In making the examination the plan was adopted of grading the seed into the following classes according to the character of the lint attached:—

Grade 1.	Staple below $1\frac{1}{2}$	inches in length.		
Grade 2.	„ from $1\frac{1}{2}$ to $1\frac{3}{4}$	„ „ „	
Grade 3.	„ „ $1\frac{3}{4}$ „ 2	„ „ „	
Grade 4.	„ over 2	„ „ „	not even.
Grade 5.	„ „ 2	„ „ „	even.
Grade 6.	„ „ 2	„ „ „	very even.

For this purpose 100 seeds were taken haphazard from the bulk of the seed-cotton from the selected plants on the experimental plots and divided into the above grades, with the following results:—

Botanic Station (St. Vincent Rivers' Seed). Grown from selected plants.

Grade 1	12	per cent.
„ 2	18	„ „
„ 3	60	„ „
„ 4	0	„ „
„ 5	10	„ „
„ 6	0	„ „
	100	

In addition, similar selections were made on lots of the best grades of seed-cotton obtained from two of the estates in the island which had produced the finest lint and the largest yield of cotton during the season under review.

The examination of cotton produced by these estates resulted as follows:—

Yepton's (St. Vincent Rivers' Seed).

Grade 1	0	per cent.
„ 2	20	„ „
„ 3	13	„ „
„ 4	3	„ „
„ 5	10	„ „
„ 6	24	„ „
	100	

Gilbert's ('Gilbert's' Seed).

Grade 1	0	per cent.
„ 2	4	„ „
„ 3	19	„ „
„ 4	14	„ „
„ 5	34	„ „
„ 6	29	„ „
	100	

The seed-cotton from Gilbert's estate was grown from the type of seed known as 'Gilbert's;'* that from Yepton's was grown from imported St. Vincent Rivers' seed.

The graded seeds obtained in the examination were then submitted to careful examination. All seeds which had been classed under grades, 1, 2, and 4, were rejected as being undesirable by reason of the attached lint being either too short or lacking in evenness. On the other hand, seeds which had been classed under grades 3, 5, and 6 were kept and planted out on the experiment plots, in the hope that plants producing superior qualities of lint might thereby be propagated. As a result of the above selection experiments, 239 specially selected seeds were sown, their grades and origin being as follows:—

	Botanic Station.	Yepton's.	Gilbert's.
	St. Vincent Rivers' seed.	St. Vincent Rivers' seed.	Gilbert's seed.
Grade 3 ...	60	43	19
„ 5 ...	10	10	34
„ 6 ...	0	24	29
Total ...	70	77	82

An interesting feature of the above results is the remarkable constancy which the proportion of what has been regarded as desirable seed bears to the total amount examined. The average is 80 per cent., and in each individual case the actual return only differs from that figure by a very small amount.

The seeds planted out at the experiment station were kept separate in respect of their origin, and in the picking season of 1907, seed-cotton produced in respect of the above grades became available for examination. The seed-cotton from each of the above grades was examined at the Government

* The origin the strain of seed known as Gilbert's has several times been stated in Departmental publications but, for convenience of reference, may once again be quoted. It was forwarded at the request of Dr. Watts to Messrs. A. J. Comacho & Co. by the British Cotton-growing Association in 1903. A portion of this seed came into the hands of Mr. Anderson of English Harbour, Antigua. In 1904 Gilbert's estate obtained seed from Mr. Anderson. From this crop at Gilbert's, seed was saved and distributed by the Botanic Station under the name of Gilbert's. The particular characteristic whereby the lint produced from this type of seed differs from that grown from St. Vincent Rivers' seed, is that it is longer and more silky, though not as strong and robust. The greater length of this type of lint is well shown in the above results.

laboratory, Antigua, and divided into grades in the same way as the parent seed had been. The results obtained are given in tabular form below :—

TABLE I.

Percentage of each grade in cotton reaped.	ORIGIN OR TYPE OF SEED USED AND GRADE OF SEED SOWN.							
	Botanic Station.		Yepton's.			Gilbert's.		
	St. Vincent Rivers' seed.		St. Vincent Rivers' seed.			Gilbert's Seed.		
	per cent.		per cent.			per cent.		
	Gr. 3.	Gr. 5.	Gr. 3.	Gr. 5.	Gr. 6.	Gr. 3.	Gr. 5.	Gr. 6.
Grade 1	...	..	...	...	...	...	..	...
„ 2	26·0	10·0	35·0	40·0	5·0	15·0	10·0	10·0
„ 3	74·0	50·0	65·0	60·0	65·0	40·0	65·0	80·0
„ 4	...	...	...	..	...	...	...	..
„ 5	...	..	...	...	...	...	25·0	...
„ 6	...	40·0	...	...	30·0	45·0	..	10·0
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

The determination of the grades in each of the above cases was performed on twenty seeds, except in the case of the seed-cotton from Botanic Station grade 3, where twenty-three seeds were taken.

A striking feature of all the samples of cotton examined was the even character of the lint. In only one case, namely, that of Yepton's grade 5, did the samples show any tendency towards unevenness. In the majority of cases, the lint was remarkably even.

In examining the above results it is, in the first place, of interest to ascertain what is the proportion, in the various samples, of what has been regarded as desirable seed, i.e., grades 3, 5, and 6.

The results are as follows :—

TABLE II.

Origin and grade of seed sown.	Proportion of desirable seed in cotton reaped.
Botanic Station (St. Vincent Rivers' Seed) Grade 3 ...	74·0 per cent.
" " " 5 ...	90·0 " "
Yepton's (St. Vincent Rivers' Seed) Grade 3 ...	65·0 " "
" " " 5 ...	60·0 " "
" " " 6 ...	95·0 " "
Gilbert's (Gilbert's Seed) Grade 3 ...	95·0 " "
" " " 5 ...	90·0 " "
" " " 6 ...	90·0 " "
Mean proportion of desirable seed	82·4 per cent.

Regarding the results as a whole. it may be safely said that the influence of the selection is marked, though this is more strongly evidenced in some cases than in others.

In the case of the cotton raised from Botanic Station St. Vincent Rivers' seed, that grown from grade 3 has evidenced a slight falling off from the general character of the parent seed sown, the original seed sown containing 80 per cent. of desirable seed, while the produce reaped contained only 74 per cent. On the other hand, the effect of the grading is marked, since 74 per cent. of the seed reaped has come true to the type of seed planted.

With grade 5, on the other hand, a very distinct improvement is noticeable, 40 per cent. of the seed-cotton obtained being of the specially long type sown.

With Yepton's St. Vincent Rivers' seed, grades 3 and 5 seem to show evidences of a falling off in quality. With grade 6, on the other hand, a marked improvement is noticeable.

As judged by these results, there appears some reason to believe that St. Vincent Rivers' seed evidences a distinct tendency to throw back in the direction of shortness of staple —a tendency which will have to be vigorously combated by selection.

The results obtained with Gilbert's seed are somewhat anomalous, for though the selection has in every case increased the percentage of desirable seed in the seed-cotton produced, yet the greatest increase in length of staple is shown by seed raised from grade 3, the parent seeds of higher grade showing an apparent reduction in length in the offspring. The suggestion is made that the result may be attributable to accidental mixing in seed the sown.

A re-selection on similar lines as before was made from the seed-cotton obtained in the above experiments, but a slight alteration was made in the plan of grading. The three types of seed sown were:—

Type 1	Length 50-55 mm. (i.e., over 2 inches), and even in character.
„ 2	Length 45-49 mm. (i.e., $1\frac{3}{4}$ to 2 inches), and even in character.
„ 3	Length 45-49 mm. (i.e. $1\frac{3}{4}$ to 2 inches), and particularly even in character.

The third type was introduced with the object of endeavouring to breed a strain of cotton answering to the standard laid down by Mr. A. H. Dixon, Managing Director of the Fine Spinners' Association, during his visit to Antigua in the spring of 1906.

The number of seeds of the above types selected from each of the grades of seed-cotton reaped is given in the following table:—

TABLE III.

		Botanic Station.	Yepton's.			Gilbert's.		
		St. Vincent Rivers' seed.	St. Vincent Rivers' seed.			Gilbert's seed.		
	Gr. 3.	Gr. 5.	Gr. 3.	Gr. 5.	Gr. 6.	Gr. 3.	Gr. 5.	Gr. 6.
Type 1	...	5	...	2	10	6	4	2
„ 2	4	10	10	13	10	10	9	10
„ 3	1	...	...	...	10	1	3	10

TOTAL:—Type 1 ... ... 27 seeds.
„ 2 ... ... 76 „
„ 3 ... ... 25 „

Each of these seeds was sown in a special nursery plot at Skerrett's, a tally being kept of each individual plant raised in this way.

In the coming picking season the seed-cotton from the above sowings will be again examined in order to ascertain to what extent continued selection on the above plan influences the character of the staple produced. During the course of the work of selecting seed for these experiments a quantity of cotton seed was obtained, the pedigree of which was, to

a certain extent, ascertained, and which seed might be relied on to give cotton of superior quality.

After removal of the seed required for experimental cultivation, the bulk, amounting to some 13 lb. of seed, was distributed among the leading cotton planters of the island, with the request that they would submit it to careful trial, since it could be relied on to yield a good strain of seed for future planting on estates, and might suitably serve as a good starting point for plant selections.

Field observations made on the plants grown from selected seed lead to the conclusion that these plants, in most instances, show improved characters in general habit and vigour of growth, and these points are noticed by the growers who are raising plants from the bulk of seed just referred to.

As has already been stated, during the growing season of 1906 a fresh series of selection experiments was inaugurated and carried out by the Department, both on estates and at the experiment station at Skerrett's. In these experiments plants were first selected on account of their field characteristics; the lint produced by each plant was then subsequently examined at the Government laboratory, and seed from these plants which satisfactorily had passed both examinations was reserved for planting purposes. The methods adopted were those given by Mr. Thornton in his paper on Improvement of Cotton by Seed Selection. (*West Indian Bulletin*, Vol. VII, pp. 153-70.)

In selecting the plants, the scheme employed was identical with that used in the 1905 selection experiments carried out by the Department in Barbados, and recommended by Mr. Thornton.

The points on which each plant was judged, were as follows:—*

(1) Habit, (2) Height, (3) Number of bolls, (4) Maximum number of bolls per branch, (5) Shape of bolls, (6) Size of bolls, (7) Distribution of bolls, (8) Resistance of plant to disease.

*A simplification in judging and field notes can be effected if the plan of scoring points by numbers is adopted, as in the case of the method used in judging corn in America.

In the plan adopted by us the maximum number of marks given to any one point is 10, and the relative excellence of a plant in each of these points is indicated by the number of marks given. By adding up the value assigned to each point, the field value of a plant is seen at a glance.

To exemplify this, the result of a field selection is shown below:—

No of Plant.	Character.	Marks.	Remarks.
202	Habit	7	3 large lateral shoots.
	Height—5 feet 2 inches	8	
	Number of bolls—130. Maximum per branch, 7	10	
	Shape of bolls	8	
	Size of bolls	10	Large
	Distribution of bolls	6	
	Resistance to disease	6	Little rust; few bolls dropped.
	Total	55	

The two estates on which the selections were carried out were Sion Hill and Blubber Valley, situated in the Windward and Southern districts of the island respectively.

At Sion Hill, the selection was performed by Mr. H. A. Tempany, and Mr. T. Jackson, Curator of the Botanic Station. At Blubber Valley, and on the experimental plot at Skerrett's, Mr. Jackson was solely responsible for the field selection.

At Sion Hill, the selected plants were grown from Gilbert's seed. At Blubber Valley the plants were of mixed origin, part being Barbados and St. Vincent Rivers' seed, and part Gilbert's. The selected plants at the Botanic Station were grown from selected seed obtained in the grading selection experiments detailed above.

The areas of the field in which the selections were performed were—at Sion Hill, 6 acres ; at Blubber Valley, about 8 acres ; at Skerrett's experiment station, 0·4 acre.

The following number of plants were selected in the first instance at the various stations on account of their field characteristics :—

At Sion Hill	5	plants were selected.
,, Blubber Valley	16	,, ,, ,,
,, Skerrett's	7	,, ,, ,,

The lint produced by each of these plants was picked separately and examined at the Government laboratory according to the scheme outlined in the paper by Mr. Thornton quoted above (*West Indian Bulletin*, Vol. VII, pp. 153-70).

As a result of this examination, the following number of plants were finally selected for propagation from each of the above stations :—

From Sion Hill	2	plants.
,, Blubber Valley	8	,,
,, Skerrett's	3	,, *

The field characters of the finally selected plants from each station are given in Table IV :—

*At Skerrett's the origin of the three selected plants was as follows :—
No. 203 grown from Yepton's St. Vincent Rivers' seed Grade 6.
,, 206 ,, ,, Gilbert's seed Grade 6.
,, 207 ,, ,, ,, ,, Grade 3.

TABLE IV.—FIELD CHARACTERS OF SELECTED PLANTS.

Character.	Sion Hill.		Blubber Valley.								Experiment Station, Skerrett's.		
	No. 103.	No. 104.	No. 107.	No. 108.	No. 109.	No. 112.	No. 115.	No. 117.	No. 120.	No. 122.	No. 203.	No. 206.	No. 207.
Habit ...	Very regular	Fairly regular	Regular	Regular	Regular	Fairly regular	Regular	Regular	Regular	Regular	Fairly regular	Somewhat irregular	Somewhat irregular
Height ...	3 ft.	4 ft. 6 ins.	4 ft. 6ins.	4 ft.	4 ft. 8ins.	4 ft.	4 ft. 6ins.	5 ft. 2ins.	5 ft. 2ins.	4 ft. 10ins	4 ft. 10 ins.	4 ft. 10 ins.	4 ft.
No. of bolls	50	50	116	130	149	108	97	90	116	130	84	165	90
Max. per branch ...	6	6	7	7	8	7	7	7	6	7	9	8	9
Shape of bolls ...	Good	Good	Fairly good	Fairly good	Fair	Good	Good	Good	Good	Good	Fairly good	Fairly good	Fairly good
Size of bolls	Rather small	Fairly large	Fairly large	Fairly large	Large	Large	Large	Large	Large	Fairly large	Fairly large	Fairly large	Fairly large
Distribution of bolls ...	Very even	Even	Even	Even	Even	Even	Even	Even	Even	Very even	Somewhat irregular	Even	Even
Resistance to disease	A little leaf-blister mite: good otherwise	Fairly good, a little rust and a few worms.	Good	Good	Good	Good	Good	Fairly good, a little rust	Fairly good, a little rust	Good	Good	Fairly good. a little rust	Good

In Table V are given the details of the examination of the lint produced by the selected plants above described.

The methods employed in the examination of the lint are those described by Mr. Thornton. The length was determined by the method already described, the measurements being made in millimetres. The proportion of weak fibre was determined by means of the weaver's comb as follows :—

'The fibres attached to the seed are first carefully straightened out by means of the fingers. They are then combed out straight, close to the seed ; and then, holding them at this point between forefinger and thumb, the loose ends are combed out straight. When the ends have been straightened, the comb can be drawn through their whole length, and the weak fibres will leave the seed, the strong ones remaining attached. The strong fibres can afterwards be detached from the seed, and the proportion of strong and weak determined by weight.'

The diameter of the fibre was ascertained by microscopic measurement, using a micrometer eye piece for the purpose.

The proportion of lint to seed was determined by means of a hand gin. The lint having been separated from the seed, the proportion of each is determined by weight.

TABLE V.—CHARACTERS OF THE LINT PRODUCED BY THE SELECTED PLANTS.

Plant No.	Estate.	Length of staple. Millimetres.			Weight of seed-cotton.	Proportion of weak fibre.	Proportion of lint.	Diameter of fibre. Millimetres.	General Appearance.		General Remarks.
		Min.	Max.	Aver.	Grammes.	Per cent.	Per cent.		Fineness.	Silkiness.	
103	Sion Hill	45	55	49·7	69·0	23·5	27·6	0·0159	...	..	
104	" "	40	53	47·0	94·0	24·7	27·3	0 0150	...	...	
107	Blubber Valley	45	55	50·0	90·0	24 2	25·8	0·0171	Good	Good	
108	" "	42	47	45·9	158·0	22·2	27·8	0·0166	"	"	
109	" "	45	51	47·9	219·0	25·2	26·5	0·0162	"	"	
112	" "	45	50	47·4	110·0	26·3	25·4	0·0163	"	"	
115	" "	45	50	47·7	147·0	22·8	24·0	0·0163	"	"	
117	" "	45	50	47·0	165·0	23 4	30·0	0·0162	"	"	
120	" "	42	47	45·6	147·0	19·8	28·0	0·0168	"	"	
122	" "	45	52	47·1	68·0	22·0	28·6	0·0162	"	"	
203	Skerrett's	40	50	47·3	181·0	27·0	23·9	0·0161	"	"	Plant grown from seed of Yepton's St. Vincent Grade 6. (See above.)
206	" "	47	55	49·3	290·0	25·5	24·5	0·0160	"	"	Somewhat soft. Plant grown from seed of Gilbert's Grade 6.
207	" "	43	49	45·8	163·0	19 4	24·6	0·0156	"	"	Plant grown from seed of Gilbert's Grade 3.

Nursery plots were established, using the seed obtained from each of the above selected plants, on the estates on which the plants had been raised. In the case of Sion Hill and Blubber Valley, half of the seed from each of these selected plants was also established in nursery plots on the adjoining estates of Rooms in the Windward district, and Orange Valley in the Southern district.

In the present growing season, work on these lines is being still further extended. Selections are being performed on the nursery plots established in seed from the selected plants on the above estates, and there appears good reason to believe that these selections may be the means of inaugurating strains of seed especially suited to the conditions obtaining in the various cotton-growing districts of the island.

Signs are not wanting that the importance of selection is being widely grasped by cotton planters, and the advantage of planting suitable strains of locally raised seed is becoming appreciated, since a considerable proportion of growers have signified their intention of planting seed of their own raising and selection for the ensuing crop.

COTTON SELECTION EXPERIMENTS IN ST. KITT'S.

Up to the present year no systematic attempts at cotton selection experiments have been carried out in St. Kitt's. In 1906 some selections were performed by Mr. F. R. Shepherd, the Agricultural Superintendent, on the experimental cotton plots at La Guerite experiment station.

The following memorandum by Mr. Shepherd gives an account of the mean results obtained in this respect:—

Twelve cotton trees of good habit, with an average of 150 bolls were selected in the field of cotton from Rivers' seed, that had been grown at La Guerite for three years.

The trees were selected in December 1906, and the seed-cotton was picked carefully from them. Unfortunately, however, by some mistake, the cotton from each tree was not kept separate.

The actual yield of seed-cotton was 12 lb.—an average of 1 lb. to a tree—which was strong evidence of their good yielding qualities.

This seed-cotton was sent to Barbados in January 1907, for examination by Mr. Thornton, and his report stated that the sample contained different types of cotton, and the length varied between 32 and 50 mm. He suggested that the sample be carefully gone over and all short lint discarded, and the remaining seeds sown in a special plot for selection next season.

This was done, and seeds were selected that bore lint 2 inches in length. Enough of these seeds were obtained to plant a plot of $\frac{1}{10}$ acre in the experiment station at La Guerite.

The plants grew well; seven were selected from these for their field habits and number of bolls. The cotton from these was kept separately and was examined by Mr. Tempany on his visit to St. Kitt's, at the end of November.

This selection plot has already yielded 114 lb. of seed-cotton equal to 1,140 lb. per acre, and it bids fair to give another 50 lb. from a second picking.'

During the present season, selection experiments in St. Kitt's have been recently inaugurated on the same lines as those detailed above. The experiments were carried out at the La Guerite experiment station and Conaree estate. At La Guerite twenty-seven plants, and at Conaree eleven plants were selected on the lines detailed above. The selections were performed by Mr. F. R. Shepherd and Mr. H. A. Tempany. Sufficient time has not as yet elapsed to permit of the examination of the lint from the selected plants, but there is reason to hope that the experiments may be the means of inaugurating strains of cotton thoroughly suited to the conditions obtaining in St. Kitt's.

If, as a result of these experiments, high-grade, disease-resistant strains of seed are inaugurated through the efforts of the Department, the time and labour expended on their performance will be justified.

TREATMENT OF COTTON PESTS IN THE WEST INDIES IN 1907.

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The pests of cotton have been the same during the year under review as in the two previous years except for the occurrence at Antigua in the latter part of the year of an insect which causes flower-buds to drop, and for slight attacks of the boll worm in Barbados, Antigua, and Barbuda.

THE COTTON WORM AND ITS TREATMENT.

The attacks of cotton worm (*Alabama* [Aletia] *argillacea*) have been very severe during the year under review, except in St. Vincent, where this insect appeared for the first time in 1907. Large amounts of Paris green were used, applied dry in a mixture with lime. The proportion of 1 to 6 was most in favour, and the use of ticklingburg bags more general than the tin shakers, the Acme bellows, or the Champion powder-guns. Ticklingburg bags are used attached to sticks or wooden handles, and without handles. The latter method seems to give more satisfaction, especially if the bags are of fair size (10 x 14 inches), and are grasped by the hand of the labourer near the top, thus leaving a certain amount of space not filled by the poison mixture, so that when the bag is shaken the mixture comes out through the cloth in a fine dust. If the bag is full, as often happens with the smaller bags on the handles, the Paris green and lime are forced through the cloth and do not come out in such a fine dust-like condition.

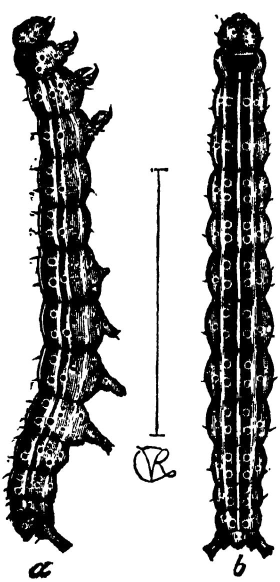

FIG. 1. Cotton Worm (*Alabama* [Aletia] *argillacea*) enlarged ; actual length indicated by hair-line.
(*a*) Seen from side ; (*b*) from above.

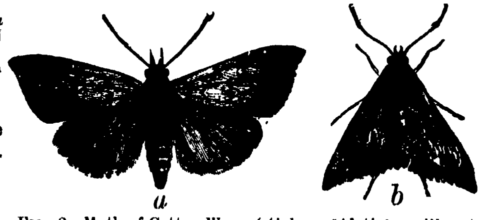

FIG. 2. Moth of Cotton Worm (*Alabama* [Aletia] *argillacea*).
(*a*) Wings spread ; (*b*) wings folded.

The tin shakers are more wasteful and seldom apply the poison in such a fine condition as the bags do.

It is often stated by planters, in favour of the tin shakers that the poison mixture is applied more directly to the plants, and the labourers do not work in a cloud of dust as often happens in the use of the bags. The effect of the Paris green and lime on the skin is irritating and it is sometimes difficult to get labourers to do the work of dusting on this account.

Old oat sacks, manure sacks, etc., are by far the most wasteful and inefficient of any of the appliances that I have seen for the application of Paris green and lime. Not only are enormous amounts of Paris green used, but it is badly distributed and falls on the plants in such a thick covering that the cotton worms will not eat the leaves, but wander away in search of more attractive food.

The most successful application, of course, is that in which a sufficient amount of the poison is held on the leaves to kill the caterpillars when they have eaten a very little of the leaf, but not enough to make the food so distasteful to them that they will not eat it.

On many estates, fields of well-grown cotton are dusted in a thoroughly efficient manner using only about 1 ℔. of Paris green (7 ℔. of the mixture) per acre for each application. This amount should be sufficient, but when tin dusters are used this amount is generally exceeded, and I have known of instances where as much as 4 or 5 ℔. of Paris green (30 to 50 ℔. of mixture) have been used per acre in one application with old manure sacks, and the cotton worms were to be seen leaving the plants and crawling out of the field in search of more agreeable food than that so thickly covered with lime and Paris green.

In St. Vincent very little, if any, Paris green was used. The cotton worm made its appearance this year for the first time on several estates, but the great numbers of Jack Spaniards (*Polistes annularis*) which preyed upon them, proved a satisfactory check. A large ground beetle (*Calosoma calidum*) was also of considerable benefit in this way.

THE SMALLER COTTON WORM.

During the year, the smaller cotton worm (*Aletia luridula*) was the prevailing pest in certain fields in Barbados. This insect also occurs in Antigua. As it is controlled by the same measures as are used for the cotton worm, the remedies do not need to be discussed. The difference in habit of these two insects is that the cotton worm pupates on the cotton plant while the smaller cotton worm pupates in the ground.

SPRAYING.

During the past season, experiments have been tried on a fairly large scale on one estate in Barbados, in the use of lead arsenate in place of Paris green as an insecticide for the control of the cotton worm. Lead arsenate is supplied by the trade in the form of a thick paste which can be applied only in the form of a spray. Up to the time of this trial, very little spraying has been done in the cotton fields in the West Indies. Paris green has almost universally been applied as a dust. The frequent showers at certain times of the year cause a con-

siderable loss by washing off the Paris green, often within a very few minutes after it is applied.

Lead arsenate is very insoluble in water. On this account it is not likely to cause injury to the leaves of plants by 'burning' or 'scorching' in the way that Paris green and London purple sometimes do when applied in the form of a spray. Lead arsenate also has much greater adhesive properties than most other arsenicals, and it is on this account particularly that extensive trials of this material will be made during the coming season.

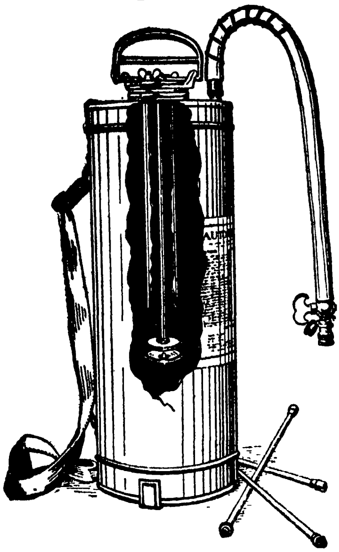

FIG. 3. The Auto-spray.

The form of sprayer likely to be most used is the Auto-spray. The principle of this machine is an air tight receptacle containing an air pump, an outlet hose and an opening through which the spray mixture is poured into the sprayer. When the poison mixture is put in and the opening closed tight, air is pumped in till a sufficient pressure is obtained, and the labourer carrying the machine sprays out the poison mixture until the pressure is reduced, when it is pumped up again.

The trials that have been made have led certain planters to believe that this type of machine is likely to prove more satisfactory than the Success knapsack sprayer or any of the barrel sprayers.

It is hoped that careful trials will also be made in the use of Paris green as a spray for comparison.

THE BOLL WORM AND CATCH CROPS.

The boll worm (*Heliothis obsoleta*) occurred in greater numbers than in previous years, and threatened to become a serious pest on a few estates in Barbados and Antigua. The corn ear-worm (*Laphygma frugiperda*) also attacked cotton bolls to a slight extent on a few estates.

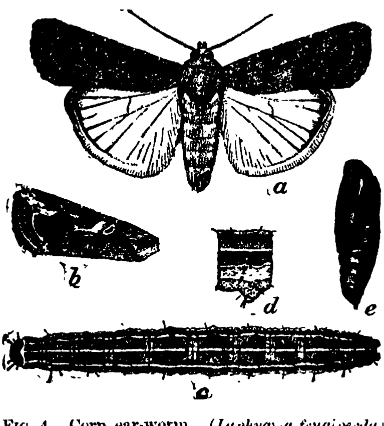

FIG. 4. Corn ear-worm. (*Laphygma frugiperda*). (*a*) Moth ; (*b*) forewing ; (*c*) larva ; (*d*) abdominal segment of larva, lateral view ; (*e*) pupa.

Both these insects prefer young corn to cotton. While corn is growing, before ears are formed, both the boll worm and the corn ear-worms feed inside the crown of the corn plant and later the young ears are attacked. This pre-

ference on the part of the insects may be used by the planters in controlling their attacks by means of trap crops.

No experiments with traps of Indian corn for the control of the boll worm have been tried in the West Indies, but the following suggestions are made with the hope that they may be tried.

For this purpose Indian corn should be planted in belts of six to eight rows across the cotton fields at every 200 to 300 feet, or, in the case of small fields, a belt of a few rows around the field. The corn should be planted some five or six weeks after the planting of the cotton.

The first boll worms will attack the corn in the crown of the plant, eating the young, tender leaves. They can be killed at this stage either by squeezing them inside the corn leaves or by the use of the poison mixture made as follows:—½ teaspoonful of Paris green mixed with 1 quart of corn meal. By means of a shaker made of a tobacco or other tin with the bottom perforated, this mixture is shaken into the crown of the corn plant. If the caterpillars continue to infest the corn and get into the forming ears, the plant should be cut and fed to stock.

The eggs of the boll worm are not laid in clusters but are attached singly to the tassel and silk of the corn, where they may readily be found with little search. A female moth will often lay as many as 1,000 eggs.

The eggs of the corn ear-worm are laid in clusters on the leaves of the corn plant.

Cowpeas are also used as a trap for the boll worm. The moths feed on the nectar of the blossoms and hide among the leaves, and it happens that a large portion of the eggs are laid on these plants.

The use of poisons for the boll worm is of no avail while the caterpillars are feeding inside the bolls; but a caterpillar may feed on several bolls before entering one, and if poison is present there is a chance that the caterpillars may get enough to kill them in making entry into a new place.

Lights and poison sweets used as traps, and poison baits have been found useless in the extensive experiments conducted in the United States, and it has also been proved that no beneficial result has been obtained by the burning of sulphur in the cotton fields.

The pupa stage of the boll worm is passed in the ground. Deep forking and ploughing will probably destroy many of the pupae.

APHIDES AND LADY-BIRDS.

The aphis or plant louse has been very abundant in certain localities in Barbados during the past season. The lady-birds and the lace-wing fly, though abundant in most parts of the island, are lacking in others. At least they are not sufficiently

abundant to control the aphis and prevent damage by their attack. This has been said to be due to the bad effect of the Paris green and lime on these insects, which when used to kill the cotton worm, is said to kill, by contact, the larvae of

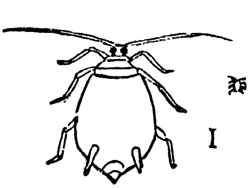

FIG. 5. Cotton Aphis (*Aphis gossypii*) much enlarged; actual length indicated by hair-line.

FIG. 6. Lace-wing Fly (enlarged)

the beneficial insects. This cannot account for the difference in the numbers of these insects in different localities, because the use of Paris green and lime is general, and if it killed

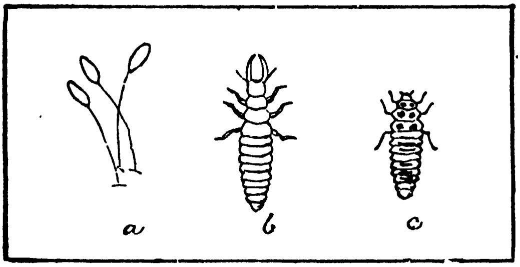

FIG. 7.—Eggs and Larvae of Cotton Aphis (*Aphis gossypii*) and Lace-wing Fly. (*a*) Eggs, (*b*) Larvae of lace-wing fly; (*c*) Larvae of lady-bird. All enlarged.

beneficial insects in one locality it would do so in all. There must be some other reason for the comparative scarcity of these insects in certain localities.

In St. Kitt's, an attack of cotton aphis was controlled by spraying with kerosene emulsion. The use of this emulsion has given very good results at a low cost.

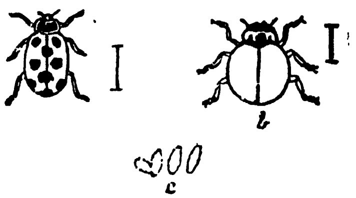

FIG. 8. Lady-birds. (*a*) Spotted lady-bird (*Megilla maculata*); (*b*) Red lady-bird (*Cycloneda sanguinea*); (*c*) Eggs of lady-bird. All enlarged.

CUT WORMS.

The cut worms (*Prodenia* spp.) have been less troublesome during the past season than in some previous years. The poison bait made of bran, Paris green, and molasses used in previous years has given good results wherever tried

COTTON STAINERS.

Cotton stainers (*Dysdercus* spp.)have not been a serious pest generally during the season, although very abundant and injurious on a few estates. The practice of collecting

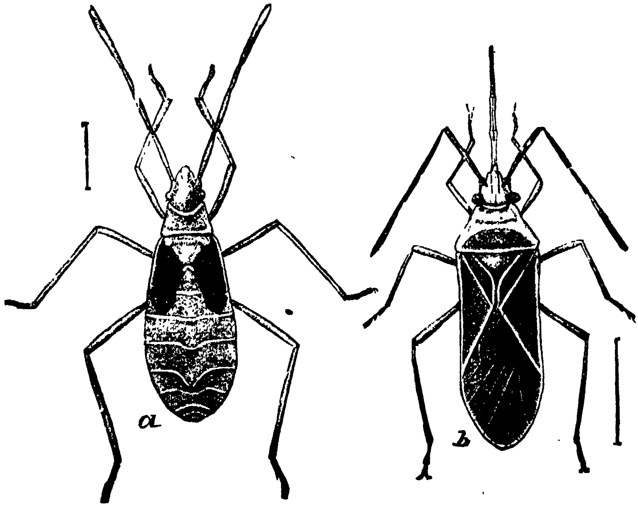

FIG. 9. Cotton Stainer (*Dysdercus suturellus*) of the United States; closely related to the several species found in the West India Islands.
(*a*) Young; (*b*) adult; actual length represented by hair-line.

these insects in the field and killing them when they congregate in the vicinity of ginning factories, storage houses, etc., has generally been sufficient to keep them in check.

THE LEAF-BLISTER MITE.

The leaf-blister mite (*Eriophyes gossypii*), though present in nearly every cotton field in those islands where this pest occurs has not caused so much damage during the past season as formerly. This is probably largely due to the fact that greater attention is paid each year to the prompt destruction of the old plants when the crop is finished, and the greater care to pick off and destroy the first infested leaves that appear. The use of sulphur and lime is not general, although where carefully tried throughout a season it has given good results. These mites attack the leaves while still in the bud, and remain in the blisters until full-grown, when they emerge and travel over the surface of the leaves and stems, to infect new buds where they may be killed by coming in contact with the sulphur.

THE RED MAGGOT.

The red maggot (*Porrichondylæ gossypii*) has not been reported during the year to be doing any damage. This pest has occurred only on a small area in each year, and has not generally been seriously abundant on the same area in two successive seasons.

The only remedy practised is that of cutting out attacked stems and branches, and the only preventive caution to be taken is the exercise of great care that the bark of the plants be not broken or bruised.

THE BLACK SCALE.

The cotton black scale (*Saissetia* [Lecanium] *nigra*) has been a serious pest during the season. Spraying has been tried on one estate at least, the rosin-whale-oil soap mixture being used. The cutting out of infested plants has also been tried, but the most satisfactory method is perhaps clean culture, or a system of prevention. All old cotton on the estate should be destroyed some weeks before the planting season for the new crop commences.

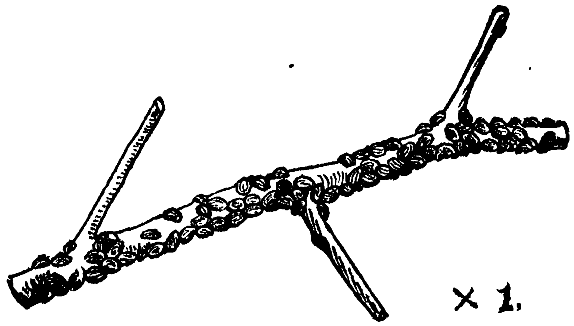

FIG. 10. Scale Insects on Cotton: natural size.

During the past two years it has been noticed that a native parasite of the black scale has been increasing in abundance, and it is hoped that this insect may soon prove an efficient check on the black scale. Through the kindness of Dr. L. O. Howard, Chief of the Bureau of Entomology, United States Department of Agriculture, this parasite has recently been identified as *Zalophothrix mirum*. In order not to destroy the parasite, it would be well to leave the old cotton plants in the field for about ten days after cutting or pulling them up, before burning or burying them. This will allow time for many of the immature parasites to complete their development and escape; thus providing for a more rapid parasitism of the scales when they appear on the succeeding crop.

DISCUSSION.

Dr. FRANCIS WATTS drew attention to the fact that 'Jack Spaniards' had done considerable amount of good in St. Vincent, and asked Mr. Ballou if he was able to state whether the insect there was a different species to that in the Northern Islands, where similar results had not been observed.

Mr. BALLOU stated that he had not, as yet, received or obtained satisfactory specimens of those insects known in the various islands as 'Jack Spaniards,' and it was suggested by

the President that as complete a series as possible of these insects might be sent to Mr. Ballou, and also that an interchange of specimens between the different islands might assist in satisfactorily answering the question raised.

Examination of specimens on hand in the Conference Hall showed that the 'Jack Spaniard' of St. Vincent was identical with the 'wild bee' of Barbados, which has given similar beneficial results.*

Mr. SANDS (St. Vincent) confirmed the statement that the 'Jack Spaniard' had been of considerable service in controlling attacks of cotton worm at St. Vincent, but thought that the time had arrived when all cotton planters should have on hand a supply of insecticides. He also verified the similarity between the 'wild bee' of Barbados and the 'Jack Spaniard' of St. Vincent.

The PRESIDENT, in summarizing the discussion, referred to the necessity of taking all possible precautions to keep out the Mexican boll weevil from these islands, which he stated was a terrible pest of cotton in some areas of the United States, and was also doing damage in the island of Cuba. He said he believed this to be the most destructive pest that has been known to attack cotton, and referred to statements in respect to the amount of damage caused by this pest made by Dr. L. O. Howard, Chief of the Entomological Bureau of the United States Department of Agriculture, and reprinted in the *Agricultural News* (Vol. VI, p. 402). He also referred to the unadvisability of importing cotton seed for any purpose into these islands from Cuba, owing to the presence of this pest.

* Examination in the Entomological Laboratory of the Imperial Department of Agriculture of specimens since received from St. Vincent has shown that the 'Jack Spaniard' of that island is the same species as the 'wild bee' (*Polistes annularis*) of Barbados [ED. *W. I. B.*]

ORIGIN AND ESTABLISHMENT OF THE BARBADOS CO-OPERATIVE COTTON FACTORY.

BY HON. F. J. CLARKE, C.M.G., M.A.,

President of the Barbados Agricultural Society.

With a view to encouraging the cultivation of cotton and onions in this island, the Imperial Commissioner suggested that the Barbados Agricultural Society should appoint a Committee to co-operate with the Imperial Department of Agriculture with that object.

This Committee was appointed on February 6, 1903; it consisted of seven members, Sir Daniel Morris being one, and I had the honour of being the Chairman. Subsequently four others were added to the Committee.

The Committee at once decided that the first step to be taken in encouraging the cultivation of cotton was the erection of a ginnery. There were then a few trial plots of cotton which had been planted at the suggestion of the Imperial Commissioner. The Committee was lent one of three gins and one of three baling presses sent out to the Imperial Commissioner by the British Cotton-growing Association.

On the application of the Committee, the Government lent them a wooden building which had been erected as a smallpox hospital, which was no longer required for that purpose, and a site on the Pierhead for the erection of the ginnery. The British Cotton-growing Association lent them two gins.

The Legislature voted and placed at the disposal of the Committee £250 for erection purposes.

A second-hand engine and boiler and the necessary fittings were bought, and the ginnery on its completion was formally opened by Lady Morris on July 31, 1903. The result of the first year's working was satisfactory, and as it was found that the next year's cotton crop would be about 800 acres, the Committee decided to enlarge the ginnery.

The British Cotton-growing Association lent them three more gins and a cotton seed disintegrator; the Legislature voted a further sum of £120, and the British Cotton-growing Association gave £100 to defray the cost of erection.

The enlarged ginnery was equipped with six gins, a baling press, and a seed disintegrator. It was opened on January 25, 1904.

During the first two years of their work, the Committee were not only helped by the Government in the erection and enlargement of their ginnery, but money was lent them by the Government to purchase seed-cotton from small growers, and to pay their working expenses. The Imperial Commissioner of Agriculture also lent money for this purpose.

The growers of cotton were now perfectly satisfied with the results obtained so far, and the area in cotton for the

season 1904-5 appeared likely to be very much larger than that of the previous year. The Committee therefore decided that the time had arrived when the cotton industry should be carried on without any government or other assistance; they therefore called a meeting of cotton growers and proposed to them that they should form a co-operative company to take over and work the ginnery. This was done, and thus there came into existence the company known as the Barbados Co-operative Cotton Factory, Ltd., which was registered under the Companies Act on August 16, 1905, with a capital of £800 divided into 1,600 shares of 10*s*. each.

On the formation of the company, the Government agreed to accept £600 first debenture bonds at 6 per cent, redeemable in twenty-one years, for the £683 which they had from time to time lent to the Committee, and the British Cotton-growing Association agreed to accept £150 for the six gins and the disintegrator which they had lent.

The company worked the ginnery taken over from the Committee for a year, but the directors found that it would be wholly inadequate to deal with the cotton that would be sent to them the following season; and with the increased amount that was certain to be grown in the future. The directors therefore proposed to the shareholders that the capital of the company should be increased so as to erect a very much larger ginnery. This was agreed to on March 20, 1906, and it was decided to issue 16,000 shares at 10*s*. each. Of this number however, only 10,524 were issued.

The directors bought the site where the factory stands, ordered the necessary machinery, and commenced work on the new buildings on May 4, 1906. The factory was opened on January 22, 1907.

The working of the factory has been highly satisfactory both to the cotton growers who have had their cotton ginned there, and to the shareholders who have received good dividends.

The factory is equipped with a double expansion engine, a Stirling water tube boiler, twenty-four gins, a hydraulic baling press, and a seed disintegrator.

It is hoped that in the near future, oil-extracting machinery will be added.

From small beginnings and through many struggles, there has come into existence the largest Sea Island cotton ginnery in the world.

The following table showing the growth of the cotton industry in this island is of interest as illustrating the increasing demand for ginning facilities of which I have spoken in giving the history of the cotton factory :—

TABLE SHOWING THE AREA PLANTED IN COTTON, THE YIELD, AND THE ESTIMATED VALUE OF THE COTTON EXPORTED FROM BARBADOS FROM 1902-7.

Year.	Area planted.	Lint. Pounds.	Seed. Pounds.	Value of lint.	Value of seed at £5 per ton.	Total value.
				£	£	£
1902-3	16	5,550	13,450	..	...	318
1903-4	800	192,061	472,510	12,388	1,055	13,443
1904-5	1,647	344,232	846,882	20,869	1,890	22,759
1905-6	2,000	479,418	1,179,468	30,363	2,633	32,996
1906-7	5,000	853,408	2,042,840	72,326	4,560	76,876

The factory has turned out the following amounts of lint:—

Season.	Pounds.	
1902-3	4,826	When under the direction of the Cotton Committee.
1903-4	104,926	
1904-5	215,500	
1905-6	328,341	When owned by the company.
1906-7	538,507	

For the first three months of the season 1907, 66,667 lb. have been turned out. The factory purchases seed-cotton chiefly from small growers at a price which is generally about one-fourth of the price of lint on the day of purchase. Cotton is ginned, baled, and shipped for growers, and the money received from England and paid to them at, an inclusive price of 3¼c. per lb. of lint.

The seed is either taken over from the growers at £5 per ton, or sent to Messrs. H. E. Thorne & Son's oil-extracting works, at their option. In the latter case the growers are paid a price per ton of seed regulated by the price of oil according to a scale agreed upon between Messrs. Thorne & Son and the directors of the factory. This, however, does not fall below £5 per ton, and they have returned to them 1,700 lb. of cotton-cake-meal for each ton of seed.

The factory also sells selected and hand-picked cotton seed at 3*d.* per lb. to growers in this island and at a slightly higher price to others. The seed from the finest varieties is reserved for this purpose.

Advances are made to growers on the cotton sent by them to be ginned, to the extent of half the value of the lint at a low rate of interest, and to the extent of three-fourths of the price of lint at a slightly higher rate.

Paris green is ordered for growers who wish to get it in large quantities, and a stock of it is kept for those who buy in small quantities.

The directors endeavour to do everything in their power to help cotton growers.

RICE INDUSTRY.

EXPERIMENTS WITH RICE AT BRITISH GUIANA.

BY PROFESSOR J. B. HARRISON, C.M.G., M.A., F.I C., F.C.S., F.G.S.,
Director of Science and Agriculture, British Guiana.

Experiments with rice were first started at the Experimental Fields in 1903. It was considered desirable to obtain from other countries the best of the varieties of rice there cultivated, and to submit them to trial as to their yielding powers under conditions similar to those existent in the rice-fields of the coast-lands of the colony.

For this purpose we have experimented with about 100 varieties of seed-rice obtained from the United States, Ceylon, Java, and India, and compared them with the Creole kinds. We soon found that there are very marked differences between the varieties in their periods of growth, their yields per acre, and especially in the qualities of the rice they produce.

The area laid out in paddy-beds for experiments with promising varieties is about 9 acres, whilst some 520 yards of a trench about 10 feet broad are utilized for small-scale trials with varieties of less promise.

Advantage has been taken in the paddy-beds of the way they are laid out to institute a series of comparative trials between various phosphatic manures. Each paddy-bed is longitudinally divided in its middle into halves by means of a drainage trench. One-half of each bed has been left not manured, whilst the other half has been manured for each crop with superphosphate of lime, slag phosphate, or with basic superphosphate of lime.

No experiments have been made with either nitrogenous or potassic manures as it was considered that the irrigation water, of which about 15 inches are supplied during the growth of a crop, and which contains 3·5 parts of nitrogen per million of water. would supply that substance in abundance and that the soil would supply, at any rate for the earlier crops, a sufficiency of potash. But the crops now show signs of decreased yields, and we intend, by simple modifications in our experiments, to examine into the results of additions of potash salts and of lime to the soil of the paddy-beds.

Our variety-trials have resulted in weeding out, owing either to defects in yields or in the character of the rice as determined by examination by rice-milling experts, many of

the varieties experimented with. The varieties we have selected and retained with their yields per acre in paddy for each of the years 1905, 1906, and 1907, and their mean yields over either two or three crops are shown in the following:—

Variety.	Yields in Bags of 120 lb.			
	1905.	1906.	1907.	Mean.
British Guiana Rices.				
Creole Rice	34	42	33	36
Berbice Creole Rice ...	23	22·5	18	21
Ceylon Upland Rices.				
No. 1	18·5	47	20	28·5
„ 3	31·5	45	32·5	36
„ 4	27·5	34	32	31·2
„ 6	42·5	42·5	32	39
„ 34		32·5	15	23·5
Ceylon Lowland Rices.				
No. 17	38	28	15	21·5
„ 18		41	26	33·5
„ 39		34	21	27·5
„ 41		36·5	16	26
„ 43		37	13	25
Louisiana Rices.				
Carolina Golden Grain...	22 5	19	17	19·5
Carolina		24	14	19
Japan (dwarf)	20	11	7·5	13
Honduras	22·5	23	13	19·5
East Indian Rice.				
Sura Dhani	34	34	35	34·5

The order of these yields are therefore:

1. No. 6 Ceylon Upland Rice (39 bags).
2. Creole Rice and No. 3 Ceylon Upland Rice (36 bags each).
4. Sura Dhani (34·5 bags).
5. No. 18 Ceylon Lowland Rice (33·5 bags), and
6. No. 4 Ceylon Upland Rice (31·2 bags).

Messrs. Wieting and Richter, the enterprising owners of the Georgetown Rice Factory, kindly examined by milling, samples of the varieties raised in 1906, and expressed their opinion that of the imported varieties 'Nos. 6, 4, and 75 (Sura Dhani) are the best suited for the local trade, the first-named especially being the long-grained kind which is saleable.' This opinion is of great importance, as it shows that No. 6—the heaviest yielding variety we have cultivated—is also the one most suitable for our local market.

The mean results of the manurial trials have been as follows:—

Manure.	Bags of Paddy (120 lb.) per acre. Mean. 1905-7
No superphosphate .. .	29 5
With superphosphate .	29·3
No slag phosphate	29·7
With slag phosphate	29·5
No basic superphosphate	27·7
With basic superphosphate .	28·9

During these trials 100 comparisons without and with phosphates have been made, sixty-three of which resulted in higher yields on the plots dressed with phosphates than on those not so dressed. In the case of basic superphosphate, 69 per cent. of the manurings, in that of superphosphate 64 per cent., and in that of slag phosphates 52 per cent. were accompanied by increased yields. From this it may be concluded that dressings with phosphates are advantageous to rice.

The relative advantages of the different forms of phosphatic manuring may be inferred by eliminating from

consideration the results where the manurings were followed by lessened yields. The following table gives the mean results thus arrived at:—

Manure.	Bags of Paddy (120 lb.) per acre. Mean. 1905-7.
Without superphosphate	31·5
With superphosphate	33·2
Without slag phosphate	31·4
With slag phosphate	33·7
Without basic superphosphate ...	24·8
With basic superphosphate ..	27·2

This shows that, presuming the plots which received phosphatic manurings were of equal fertility to those not so manured, increased yields of 4·7, 7·3, and 9·6 per cent. are due, respectively, to the dressings with superphosphate, slag phosphate, and basic superphosphate.

Reference was made, in the papers dealing with sugar-cane experiments, to the somewhat peculiar nature of the soil-waters of the paddy fields which may have affected to some extent the results of the trials with phosphatic manurings.

Trial was made in 1907 of a mode of planting strongly recommended by the Immigration Agent in India for adoption in British Guiana. This consists in planting singly, carefully selected plants in the holes in place of two or three plants as is usually done here. The following were the comparative results obtained:

Variety.	Bags of Paddy (120 lb.) per acre.	
	Single plant to a hole.	Two or three plants to a hole.
Colony Creole Rice ...	37·2	32·3
Berbice Creole	30·0	17·2
Ceylon Upland Rice No. 3 ..	32·0	32·6
Ceylon Upland Rice No. 4 ...	28·5	31·3
Ceylon Upland Rice No. 6 ..	38·0	32·5
Sura Dhani	28·7	33·7

As is usually the case in experiments of this sort, the results with different varieties were conflicting. The mean yield of

the singly planted plots was 32·4 bags of paddy per acre whilst that of the more crowded plots was 29·9 bags.

The paddy obtained from the best of the varieties in these experiments is given free of charge to bona fide planters of rice for use as seed-rice. In 1907, 215 rice growers were supplied with seed from selected varieties. The amount distributed was about 4 tons in weight.

It may be of interest to members of the Conference to compare the costs of the experiments in British Guiana with sugar-canes and with rice (omitting salaries, but including costs of labour and wages of foremen) with those of experiments of like nature in their own colonies. The mean annual cost of the Government Experiments in sugar-cane during the period 1905-7 was $2,538, whilst that of experiments with rice was $398.

DISCUSSION.

Hon. B. Howell Jones (British Guiana) referred to the great advance that the rice industry of British Guiana had made during the past few years. Rice cultivation began so far back as 1865 when the Hon. William Russell, a well-known agriculturist, started to grow rice on a small scale on one of the northern estates. Soon after, a company was formed to grow rice on certain lands on the Demerara river. The cultivation of rice, however, gradually ceased to be remunerative. The rice crops in India were very large, and the merchants of Georgetown could import rice at as low a figure as $3·25 per bag. Then, too, the scarcity of labour also led to a decrease in the cultivation. The industry, however, did not die altogether. Rice continued to be grown by the coolies in several districts on the Essequebo, where the conditions were favourable to its growth. In 1902, Mr. A. R. Gilzean, then manager of plantation Anna Regina, wrote an article on 'Rice Growing and Rice Cultivation in British Guiana,' which appeared in the journal of the Royal Agricultural Society of British Guiana and also in the *West Indian Bulletin* (Vol. II, pp. 278-84). In that year, the price of rice had risen considerably owing, in a great measure, to the shortage of the rice crops in India, and the area under cultivation was increased enormously. Hearing of the advantage to be gained by growing rice, a large number of people began to cultivate rice on lands which were very improperly drained and where there was no inundation at all. In many of these instances the crops absolutely failed, resulting in heavy financial loss to the growers. But in other cases the growers were successful, and in the last seven years the increase of the industry had been enormous. In 1898-9, the yield was 4,653 tons. In 1906-7 it had risen to 17,443 tons. The Customs export returns showed that from April 1, to December 31, 1907, the rice exported from British Guiana amounted to 4,185,228 ℔., of the value of $114,488. Of this amount, they had shipped to the British West Indies 3,708,646 ℔., of the value of $101,280. Those figures showed how rapidly the industry had developed.

TABLE I.

Return showing the Quantity and Value of British Guiana Rice exported from April 1, to December 31, 1907.

Countries to which Exported.													
Total.		United Kingdom.		British West Indies.		Germany.		French Guiana.		French West Indies.		Dutch Guiana.	
Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
lb.	$	lb.	$	lb.	$	lb.	$	lb.	$	lb.	$	lb.	$
4,185,218	114,488·55	245	6·40	3,708,646	101,280·30	36,700	1,050·00	238,964	6,439·55	153,780	4,660·00	46,893	1052·30

From April 1 to December 31, 1906.

Countries to which Exported.							
Total.		British West Indies.		United States.		French Guiana.	
Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
lb.	$	lb.	$	lb.	$	lb.	$
1,592,252	40,302·21	1,560,077	39,400·36	40	1·60	32,135	900·25

TABLE II.

RETURN SHOWING THE QUANTITY OF RICE IMPORTED INTO BRITISH GUIANA FROM APRIL 1 TO SEPTEMBER 30, 1907 (SIX MONTHS).

Quantity.	Rate of Duty.	Duty.	
lb.		$	c.
1,455,865	35c. per 100 lb.	5,095	53

Hon. W. FAWCETT (Jamaica) mentioned that rice cultivation was carried out on a very small scale by coolies at Jamaica. The original rice mills had gone out of operation for some time.

Mr. A. F. CLARK (Trinidad) stated that there were no statistics available as regards the area of rice cultivation at Trinidad. Rice was grown by East Indians for their own use in the Caroni district, and at San Fernando. The cultivation has been increasing gradually.

The PRESIDENT referred also to the cultivation of small areas of rice in the island of St. Lucia.

RUBBER INDUSTRY.

Mr. J. H. HART (Trinidad) in a brief review of the position of the Rubber Industry of Trinidad and Tobago made reference to the paper prepared for the Conference held at Jamaica last year (*West Indian Bulletin*, Vol. VIII, pp. 195-9) in which mention was made of *Castilloa* or Central American rubber, *Hevea* or Para rubber, *Manihot*, *Ficus*, *Landolphia* spp., and *Funtumia* or Lagos silk rubber. Reference was also made to small exports of balata (the produce of *Mimusops globosa*) from Trinidad.

An increase of acreage under rubber cultivation was taking place and some gratifying results had been obtained. The rubber industry appears to be now fairly well established in Trinidad, and there is a prospect of success.

Mr. HART then read a brief paper on 'A new rubber-producing plant (*Odontadenia speciosa*, Benth.) :—

During studies as a cadet at the Experiment Station, St. Clair, Mr. R. Fifi tapped the stems of a large specimen of *Odontadenia speciosa* growing near the office, and produced a small piece of rubber. Subsequent operations confirmed his discovery. The stems (December, 1907) bleed freely, and coagulation occurs naturally when a small quantity of clean water is added,

The plant is a native of Trinidad and occurs on lands which are practically valueless for other crops. In its flowering season it is one of the most beautiful of the native plants, producing abundant panicles of large yellow flowers, with a dark rosy centre, in form somewhat resembling those of *Allamanda* and equal in size to those of *A. Schotti* and *A. Williamsii*. It belongs to the Natural order *Apocynaceae* which includes the rubber producers *Funtumia*, *Landolphia*, *Fosteronia*, etc.

The plant will probably be unsuited for general cultivation, but if planted in suitable lands is clearly capable of affording considerable returns.

In certain positions it seeds freely but in others it bears poorly. It can be propagated by layers and by cuttings under suitable treatment.

Its natural habitat is in savannahs near swamps on the Caroni River and in the Nariva district of Trinidad.

Hon. W. GRAHAME LANG (Grenada) said that in 1906 he had imported 10,000 seeds of Para rubber from Ceylon packed in charcoal. About 80 per cent. germinated, and the plants appear to be quite promising.

Mr. J. C. MOORE (St. Lucia) mentioned the introduction of Para rubber into St. Lucia. He referred to the poor results obtained in the importation of plants in Wardian cases. He had obtained much better results by introducing Para rubber seeds from Ceylon packed in slightly damped charcoal.

The PRESIDENT said that he thought better results had been obtained in the transportation of rubber seeds in charcoal than by any other method. Importation by parcel post was advocated.

Hon. W. GRAHAME LANG stated that parcel post added to the expenses when large quantities were imported.

Mr. J. C. MOORE said that a second importation of Para seed in charcoal had given fairly satisfactory results. About 46 per cent. were raised.

Professor HARRISON (British Guiana) said that they had given up the importation of rubber seed from Ceylon, and they now got them direct from Singapore. Within the last few months he had imported 62,000 seeds, and had got nearly 82 per cent. germinating. These seeds cost on arrival about 1·2c. each. They were packed in dry charcoal in seed-boxes and were sent by parcel post to ensure the quickest delivery. The plants when ready for delivery had cost altogether 2·58c. each.

RUBBER EXPERIMENTS IN BRITISH GUIANA.

BY PROFESSOR J. B. HARRISON, C.M.G, M.A., F.I.C., F.C.S., F.G.S.,

Director of Science and Agriculture, British Guiana.

The exploitation of the rubber-producing trees indigenous to this colony and the cultivation of them and of imported kinds of rubber-producing plants were subjects in which the late Government Botanist, Mr. G. S. Jenman, took great interest and upon which he treated in many of his published writings.

During one of his journeys in the interior of the colony in the year 1882, he discovered that the aboriginal Indians made balls of rubber from the latex of an indigenous Sapium, closely allied to the Barbados poison tree. The Carib name of the tree is 'touckpong.' Specimens of the flowers, etc., of the tree were sent to Kew together with samples of the rubber. The tree was determined and named at Kew as *Sapium Jenmani.*

The following extracts from an article entitled 'The India-Rubber and Gutta-Percha Trees of British Guiana' written by Mr. Jenman and published in Vol. II of *Timehri* (1883), show the views he held, which views are, after a lapse of nearly a quarter of a century, slowly being acted upon :—

'. . . . . I may here again call attention to the facilities which this colony affords on all its rivers—and on that portion of them too which is accessible without difficulty or much expense, i.e., that below the falls—for the cultivation of *Hevea*. . . . . The cultivation might be successfully pursued, not only where the trees are found spontaneously, but, as well, on land of a similar, or identical character, where, through other circumstances, they are not naturally established. The labour required would be very inconsiderable, and a few hundred acres, treated with care and intelligence, would prove in the course of years a source of considerable profit to the proprietor. If planters in Ceylon and India speak hopefully, as they do, of the eventual success of *Hevea* cultivation in those countries, here, possessing all the natural conditions, and the advantages derived from an intimate acquaintance with these under the actual occupation of the trees, the success should be assured . . . . The *Hevea* cultivator should be prepared to wait for his crop, but meanwhile any trees already on the ground might be utilized and the produce sold. Seeing the increasing demand for india-rubber, with the daily extension of its application, and, particularly, the value of *Hevea* rubber, as compared with other kinds, the result of the enterprise might be looked forward to with the utmost confidence. Manufacturers will take all they can obtain, and were it only more abundant in the market, and cheaper, many new uses might be found for it . . . . The cultivation might be carried on in conjunction with wood-

cutting, plantain growing, or any other immediately remunerative industry, which would enable the cultivator to tide over the time till the trees reached the age of production . . . . . .'

Whilst the first samples of the 'touckpong' rubber collected personally by Mr. Jenman were favourably reported on, later samples collected for him were considered to be practically valueless owing to the high proportions of soft resins they contained. Later investigations have shown that the collectors of the latter samples probably mixed the latex from the true 'touckpong' with the resin-yielding latex of 'cumakaballi,' the name given by the Arawaks to many of the larger growing fig-trees of the colony. After the receipt of the report on the latter samples all interest in 'touckpong' rubber ceased for several years.

In 1902-3, Mr. H. I. Perkins, I.S.O., obtained an excellent sample of rubber from the Upper Cuyuni river. This was very favourably reported on by the Imperial Commissioner of Agriculture to whom it was submitted. Later in 1903, Sir Alexander Swettenham, then Governor of British Guiana, offered prizes for the best specimens of indigenous rubber collected in the colony. Some excellent samples were submitted in competition for the prizes, and interest in the rubber-producing capabilities of the colony was aroused.

The Agricultural Department endeavoured to introduce varieties of rubber-bearing plants from other countries and succeeded in distributing some thousands of plants of *Funtumia elastica*, and of other rubber-yielding trees in smaller numbers. In 1906, a commencement was made, by the importation of seeds from Ceylon, of attempting to commence the cultivation of *Hevea brasiliensis* on a large scale in the colony. The earlier importations from Ceylon were almost complete failures, the seeds spoiling on the journey. Resource was then had to the Botanic Gardens, Singapore, from whence large consignments have been received. The seeds are packed in dry charcoal, said to be obtained by charring rice straw, in hermetically soldered tins and are, in order to ensure rapid transit, sent by parcel post. During the past few months, we thus imported over 62,000 seeds and we succeeded in germinating 82 per cent. of them. The cost of the seeds on arrival in British Guiana was 1·2c. each, whilst when ready for delivery to purchasers the plants had cost \$2·58 per 100 to raise.

It has been stated as an objection to transit of seeds by parcel post by a previous speaker, that it added materially to the expenses when large quantities of rubber seed were imported.

An instance has lately occurred at the Botanic Gardens which might be of some interest to the members of the Conference in considering this objection. At the time that the Department imported Para rubber seeds by parcel post, a local firm imported from Ceylon 10,000 seeds by ordinary shipping opportunities. Without delay on their arrival, the seeds were transferred to the Botanic Gardens and attempts were made to germinate them side by side with the 62,000 we had just received by parcel post. Only eighteen plants were

obtained from them. The eighteen plants had cost $6·46 each when raised, and the extra cost of about $1·00 per thousand seeds for importation, incurred by utilizing the parcel post, was far more than offset by the fact that we obtained 250 plants when we utilized it at the same cost as one was raised for, where ordinary shipping facilities were made use of.

Importations of some thousands of stumps of Para rubber trees have also been made with some success, but now that the mode of importing seeds in a condition of satisfactory vitality has been demonstrated, it is not likely that resource will again be had to the importation of stumps.

Between 1902 and 1906 experimental planting of rubber trees of various sorts in limited numbers had been made at Onderneeming School Farm near the mouth of the Essequebo river, and at Christianburg, about 70 miles up the Demerara river. These tentative trials have been attended with some success.

In 1907, the Government decided to establish a rubber experimental station and the funds necessary for this and for its upkeep were voted by the Combined Court. An area of 400 acres, situated on the Aruka river in the North Western District of the colony, was selected as the site of the station. The advantages of this is, that the station is situated along part of the eastern base and rise of the Aruka hills, which there have an elevation of about 150 feet above sea-level and includes in its area the Issorora hill settlement and creek.

The Aruka hills consist of epidiorite which weathers into a red-coloured laterite with attendant formation of concretionary ironstone. Hence the top and sides of the hills are covered with considerable depths of chemically speaking rather poor soil, but one whose texture is well adapted for purposes of cultivation. The hills rise from an expanse of low-lying, more or less swampy land, which extends from their base, for a distance varying from about ½ mile to 1 mile, to the banks of the Aruka river. The configuration of the station enables various kinds of rubber-producing plants to be experimented with under very varying conditions.

Houses for the Agricultural Instructor in charge of the station and for the labourers employed on it have been erected, whilst a considerable area of the lower slope of the hill and of the low-lying land in front of it has been cleared from forest, empoldered, drained, and planted with some thousands of rubber trees.

The kinds planted include *Sapium Jenmani*, *Hevea brasiliensis*, *Funtumia elastica*, and *Castilloa elastica*.

Plantings of rubber are also being made on low-lying land, cleared from forest but not empoldered and drained, and in the forest land in places where the bush has been cut out only sufficiently to let in light down to the young plants.

The cost of establishing the station and of its upkeep during 1907, excluding the salary of the Instructor-in-charge, amounted to $2,724.

Another station is to be started during 1908-9 by an extension of the tentative plantings at Christianburg on the Demerara river.

DISCUSSION.

Hon. B. HOWELL JONES (British Guiana) said that the grant of Crown lands by the Government in British Guiana was a very simple process. Anyone could go to British Guiana and obtain a grant of land if he could show that he was a man of sufficient capital to carry out the scheme which he had undertaken. Very recently a grant of land was made to a large company in England on a term of seven years, at the end of which time they could purchase at the rate of £4 an acre. They had taken up 2,000 acres. In other cases, land was given over to persons and the price was regulated by the crop to be grown on the land. For instance, the lime industry had been taken up by another company and they were clearing and preparing the land as fast as they could. They had also acquired 2,000 acres. Another person had been treating to see if he could grow sisal, and the Government were prepared to give him the land, and at the end of a certain period they would give him a freehold. If a man went to British Guiana and showed that he was in earnest, the Government always granted him the land.

GENERAL SUBJECTS.

CENTRAL EXPERIMENT STATIONS.

DISCUSSION.

The PRESIDENT stated that he had been asked to submit, formally, for the opinion of the members of the Conference, whether it was desirable and necessary to establish a Central Experiment Station in each of the principal colonies, for the general furtherance of agricultural interests.

It was within the knowledge of the members of the Conference that, at the present time, a valuable series of experiment stations was maintained in connexion with each of the Botanic Stations. There were also experiment stations attached to the Agricultural Schools at St. Vincent, St. Lucia, and Dominica. In addition, there were experiment stations maintained in the out-districts in connexion with sugar, cacao, cotton, and other crops.

The proposal desired to be submitted for the opinion of the Conference was as follows: 'Whether, in addition to what had already been done by the Imperial Department of Agriculture, it would be of advantage in Barbados and elsewhere to establish and maintain an experiment station with a moderately large area of land attached to it, provided with suitable buildings, including well-equipped laboratories; and, in the case of the sugar islands, with machinery for carrying on experiments on a moderately large scale in crushing and manufacturing sugar; and in the case of cacao, cotton, and other crops, in drying and preparing the products in the most careful and effective manner.'

The matter was one which he regarded as of considerable importance, but he was not prepared, from financial considerations, to express a decided opinion as to the possibility of fully carrying it out. He would now invite Mr. Elliott Sealy to be kind enough to introduce the discussion in so far as Barbados was concerned.

Mr. G. ELLIOTT SEALY (Barbados) thanked the President for allowing this question to be discussed at the Conference.

It was the opinion of a great many people in Barbados that there was need for a Central Experiment Station with a considerable area of land attached, and well equipped with laboratories, machinery, and necessary apparatus for carrying out experiments on a fairly large scale, and having a proper scientific staff attached thereto; where the treatment of plants of all kinds grown in any particular island could be clearly demonstrated to planters on the spot, and where research work of all kinds could be carried on. If an experiment station of that kind could be established and carried on at Barbados in addition to the valuable work which was at

present being carried on by the Department of Agriculture, the value to the planters of the information obtained therefrom would be enormous.

The Agricultural work at present was carried on in a scattered way. Mr. J. R. Bovell (the present Agricultural Superintendent) lived at Codrington, and his office was in Bridgetown. Dodds Botanic Station was in St. Philip. A planter in need of information on a certain matter went to Mr. Bovell and he was referred to certain documents. These were very valuable, but they did not have the same effect on a practical planter as if he could go to an experiment station and see things for himself. The Committee of the Legislature, appointed to decide what should be done with the free grant of £80,000 which was made by the Imperial Government in aid of the sugar industry of the country, discussed the question as to whether it should not be devoted to the establishment of an experiment station, and very nearly recommended to the Governor that a portion of that money should be appropriated to the establishment of such a station in Barbados. They, however, did not make that recommendation. Nevertheless, he thought the opinion was stronger to-day than it was then, that we should have an experiment station on the lines indicated.

Hon. F. J. CLARKE (Barbados), in supporting the proposition, said that at Dodds Botanic Station a large amount of work had been carried out in investigations in connexion with the sugar-cane by Professor Harrison and Mr. J. R. Bovell. Having seen the valuable work done at Dodds, in 1891, a movement was put on foot to establish another and larger experiment station in the island. Sir Daniel Morris happened to be at Barbados at the time, and he strongly supported the proposal as one which would prove of immeasurable advantage to the sugar industry, and which should be supported by the Government.

It was entirely owing to the work of such stations that beet had attained and still retained its present strong position, and he hoped that before long they would see a large station in Barbados where questions affecting the sugar and other industries might be taken up.

Mr. T. W. B. O'NEAL (Barbados) suggested the advisability of having two experiment stations—one in the red-soil or ratooning district, and one in the black-soil or non-ratooning district—because the results obtained at Dodds on non-ratooning soil did not always bear out those obtained on the red soil.

Professor J. B. HARRISON (British Guiana) had no doubt that an Experiment Station such as that proposed by Mr. Sealy would be of the very highest value to planters. He suggested that a small committee might be appointed to thresh out the question and to report thereon.

Hon. W. FAWCETT (Jamaica) was also of opinion that a well-equipped experiment station would be of the greatest value in every colony, but he did not know whether in Barbados the proposal was to have a separate station independent of the

Imperial Department of Agriculture, or whether there was to be a duplication of officers. Another question to be considered was that of expenditure.

Mr. SEALY explained that it was not his proposal that the experiment station should be separate and distinct from the Imperial Department, but that it should be an adjunct of that Department, so as to be able to take its place if the Imperial Government could not continue the vote for its maintenance.

Dr. WATTS (Antigua) would not advocate anything in the shape of a model farm. What he thought was wanted was a laboratory, with a sufficient area of land attached where chemical, entomological, mycological, and geological work could be carried on easily and readily, and kept properly under control. In other words, his idea was that there should be an extension of the laboratory into the field.

He did not advocate the carrying out of a big scheme in its entirety at the start, but the gradual acquirement of land attached to the laboratory, where research work could be carried out.

Such an experiment station might be established, and it should in no sense be taken as displacing the local experiments that were at present being carried on in most of the islands, which should then be regarded as co-operative experiments, and which would create greater confidence in the results obtained. But he saw no prospect of such an experiment station in Barbados proving of more than distant use to a worker in Trinidad, Jamaica, or the Leeward Islands. Such stations should be localized. And here they were met with difficulties of expenditure on equipment, expenditure on officers, etc.

Yet he did not believe the difficulties to be insuperable if they started with the idea of getting the land and laboratory together and leaving the further development of the scheme to growth.

Hon. B. HOWELL JONES (British Guiana) mentioned that in British Guiana the land and laboratories were together, and there was hardly any necessity for the establishment of a larger central station. Many proprietors had their own chemist who carried on experiments in the analyses of sugar and soils on the estates themselves.

Professor P. CARMODY (Trinidad) said that this matter had been raised in Trinidad, and one of the chief points which arose in connexion with it was the question of expenditure, which of course would have to be borne by the Government. The cacao proprietors of Trinidad were willing to contribute to the expenditure necessary for establishing such a station.

The PRESIDENT, in summing up the discussion, stated that if the several colonies were prepared to contribute sufficent funds for the establishment of well-equipped Central Experiment Stations, he was of opinion that the circumstances would justify such a step being taken. He fully realized the difficulties that would have to be met in providing the necessary funds for purchasing land, erecting buildings, and providing for a competent staff of scientific and technical officers,

Provided the several colonies could be induced to vote the necessary funds, he regarded the establishment of Central Experiment Stations as the natural development in efforts to attain to a higher standard of agricultural development.

The following Committee was then appointed to consider the matter and to report thereon :—

Hon. F. J. CLARKE (Barbados)—(Chairman), Mr. SEALY (Barbados), Mr. T. W. B. O'NEAL (Barbados), Professor HARRISON (British Guiana), Hon. W. FAWCETT (Jamaica), Hon. FRANCIS WATTS (Leeward Islands), Hon. B. HOWELL JONES (British Guiana), Professor CARMODY (Trinidad), Mr. J. R. BOVELL (Barbados), and Professor D'ALBUQUERQUE (Barbados).

The Committee presented the following report in the afternoon session :—

REPORT OF THE CENTRAL EXPERIMENT STATIONS' COMMITTEE.

The Committee appointed to consider this question recommend :—

(1) That it is of the highest importance to the progress of the agricultural industries of the West Indies and of British Guiana that there should be one or more Central Agricultural Stations in each colony.

(2) That the officers attached to these stations should devote themselves solely to the investigation, under modern scientific methods, of the special problems affecting the agricultural industries of each colony.

(3) That it is desirable that Advisory Boards of Planters should be appointed in connexion with the management and control of these stations.

(4) That expert officers, such as an Entomologist, a Mycologist, a Veterinary Surgeon or other specialist, should be appointed to one of these Central Stations when required, and that their salaries be paid by contributions apportioned among the different colonies interested.

(5) That these recommendations be forwarded to the Governments of the various West Indian Colonies and British Guiana.

(Sgd.) F. J. CLARKE,
Chairman.

NOTES ON THE VALUE OF INTRODUCED PARASITES OR BENEFICIAL INSECTS.

BY WALTER W. FROGGATT, F.L.S.,*

Government Entomologist, New South Wales.

At a Conference of Government Entomologists held in Sydney July 8 to 10, 1906, convened by the Minister of Agriculture to consider the interstate laws dealing with the export and import of fruit and plants, and the control of insect pests, a resolution was carried by the members on 'The expediency of personal inquiry as regards parasites in California,' and it was suggested that I should be sent to report upon the work done in Hawaii and California.

Nothing further came of this suggestion, though in the meantime our Minister got a Bill through the House giving power to compel orchardists to clean up their orchards and destroy, by burning or boiling, all infected fruit. This is known as the 'Fruit Fly and Codling Moth Act.' Last June at a Conference of the State Premiers held in Brisbane, the Hon. C. Swinburne, of Victoria, proposed that the Government Entomologist of New South Wales should be sent round the world to see what methods could be discovered to deal with fruit flies, either by parasites or mechanical methods: to study other cosmopolitan pests; and to report upon the value of parasites generally.

The question of parasites had become very acute in Australia through the action of California and Western Australia. It was claimed that there were no injurious scale insects in Hawaii, California, or Western Australia; that the lantana scrub had been killed out by introduced phytophagus insects; and that the codling moth parasite from Spain was spreading all over California and doing such good work that spraying and fumigation were things of the past. I was requested to visit a large number of countries to report upon parasites and their value, particularly in Hawaii, and California, and I have spent a considerable amount of time in the field and orchards in studying the question.

I found in Hawaii that scale insects and mealy bugs were just as plentiful upon native bushes and introduced plants as they are in Australia, but as there are practically no commercial orchards in these islands, very little notice is taken of them. All the interest in Hawaii is centred upon the pests that affect sugar-cane, and the work done by the staff of the Sugar Planters' Association has been on such pests. One of the most interesting was the introduction of an egg parasite (a minute parasitic wasp) of the cane leaf hopper (*Perkinsiella saccharicida*) some three years ago, from the cane fields of Queensland, by

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* Mr. Froggatt, who was in Barbados at the meeting of the West Indian Agricultural Conference, was unanimously elected an honorary member of the Conference, and read this paper.

Messrs. Koebele and Perkins. The leaf hopper had been introduced some years before with cane from Queensland, and increased so rapidly that it did a great deal of damage in puncturing the leaves and stems. In less than two years after the introduction of its parasite there was a very marked difference in the ravages of the leaf hopper, and though there are still plenty of them in the cane fields, the pest may be said to be held in check. At the same time, altered methods of cultivation and the introduction of harder-stemmed varieties of cane may have been factors in its decrease.

The introduction of at least half a dozen different insects from Mexico to destroy the lantana scrub growing on sugar land was a daring experiment in economic entomology, and could only be attempted in a place like Hawaii, where nearly everything on the islands has been introduced from foreign lands. It had been claimed that the lantana, owing to these insects, was dying in large areas, and in others, was producing no flowers or seeds. I found plenty of evidence of the insects on the lantana foliage: the most active of which was a small leaf bug. This insect, feeding on the underside of the leaves, often defoliated the bushes; but its attacks did not prevent them from throwing out a fresh growth of foliage when the rains set in. Again, this bug is very closely allied to an indigenous species in Australia that causes similar damage to the cultivated olive: it could never be introduced into an orchard country.

The insect that is killing the lantana is the Indian mealy bug (*Orthesia insignis*) known there as the 'Maui Blight,' which is a very serious pest in other countries to tea and other plants. This was accidentally introduced into the islands many years ago, but has been artificially spread by the planters and cattle men all over the islands.

In California, I placed myself in the hands of the Horticultural Commissioners at San Francisco, and from there travelled over nearly all the fruit-growing districts. The first thing I saw in their office was a large cage full of living specimens of the large ichneumon wasp busy at work depositing their eggs in bundles of sticks containing codling moth grubs that had been placed there. This is the codling moth parasite brought by Compere from Spain, which it was claimed had been so successfully spread all over Californian apple orchards that spraying was unnecessary. The Horticultural Commissioners had the year before written to several of the Australian States, offering to supply each of them with colonies of this parasite for £1,000. It was interesting to watch the habits of this wasp in the office, but the officers were unable to show me any place where it could be seen at work under natural conditions. Later on, when visiting apple orchards in different parts of the State, I found that although great numbers had been turned out to destroy codling moth, no one had ever seen them at work in the orchards, and from their large size and dark colour it is probable that the blackbirds may eat most of them.

I found several firms manufacturing arsenate of lead in large quantities for use for the control of the codling moth, and

that most of the commercial apple orchards sprayed four and five times in the season, none of them relying upon the codling moth parasite.

It was just the same in the citrus orchards. It has been stated in the Horticultural reports that all the common scale insects were either extinct or completely controlled by the lady-bird beetles or internal parasites. Not only was fumigation carried on as a regular thing all through the Los Angeles district by the Deputy or County Commissioners in the commercial orchards for red, purple, yellow and other scales, but the trees growing in the parks and gardens were black with different scales and the attendant black fungi. In all the large packing houses I visited I found them washing or brushing their oranges for scale insects, so that from a commercial point of view the ordinary parasites of citrus pests are of little value.

Certainly there is no economic entomologist that does not know that if it were not for the many parasites that attack and destroy the injurious plant-destroying insects, there would not be a green thing on the face of the earth. But they in turn have their enemies, so that there must be limitations to their value. Each country has its particular insect fauna, but when an insect beneficial in its own country is introduced into another land, the altered conditions and surroundings may render it quite valueless.

There are several striking instances of introduced lady-bird beetles clearing out, for the time, some particular scale, but of the thousands of specimens introduced into California there are a number of species that have died out in a very short space of time.

One of the greatest experiments at present being carried on is the introduction of the egg parasites of the Gypsy and Brown Tail moths from Europe, under the able administration of Dr. Howard, working with the Gypsy Moth Commission at Boston. Both these forest moths, which have been introduced from Europe, have done an immense amount of damage in the forests of North America, while in their native land they are held in check by something. If that something can be transported to America, then thousands of pounds will be saved every year.

In conclusion, I would point out that the introduction of all kinds of insects should be cautiously undertaken and should not be carried except by fully qualified Entomologists.

NOTES ON ESSENTIAL OILS.

Lemon grass, Bay leaf, and Camphor.

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The erection of a small still at the Botanic Station, Antigua, has been the means whereby a certain amount of information has been collected concerning a few essential oils. The information available must be regarded as of a preliminary character, but it answers several questions which are frequently asked.

LEMON GRASS OIL.

From time to time small quantities of oil distilled from West Indian lemon grass have found their way to the market, but we are unaware of any substantial industry being established in the West Indies in this connexion.

At the Conference held in Barbados in January 1902, Mr. J. H. Hart exhibited samples of citronella and lemon grass oils from Trinidad. These oils were examined at the Government Laboratory for the Leeward Islands and the results are placed on record in Messrs. Schimmel & Co's Semi-annual Report for October 1902, and quoted in the *Agricultural News*, Vol. II, p. 20. Various other samples have now been prepared, and one sample procured from a small grower. Information obtained as to the results of the examination of these oils is here recorded.

Lemon grass oil is chiefly valued for the citral which it contains, this being used as the starting point for the manufacture of ionone employed in producing artificial violet perfume. The following is a summary of analyses of various West Indian lemon grass oils:—

Description of samples.	Specific gravity.	Optical rotation in 100-mm. tube.	Citral. Percent.
1. Antigua. Distilled 30. 7. 07.	·8948 at $\frac{15^\circ C.}{15^\circ C.}$	- 0·25°	75·0
2. Antigua. From grass which had been growing for four years without cutting.	·9316 at $\frac{15·5^\circ C.}{15·5^\circ C.}$	+ 3·0°	48·2
3. Montserrat oil.	·8869 at $\frac{15^\circ C.}{15^\circ C.}$	- 0·21°	74·2
4. Montserrat oil from small grower.	..	...	66·0
5. Antigua oil from young grass.	·8669 at $\frac{31^\circ C.}{16·6^\circ C.}$	- 0·25°	58·0
6. Antigua oil from mature grass.	·8668 at $\frac{31^\circ C.}{16·6^\circ C.}$	- 0·42°	69·2

Lemon Grass Oils from other sources show as follows :—

Description of samples.	Specific gravity.	Optical rotation in 100-mm. tube.	Citral Percent.
Seychelles (Imp. Inst.) No. 1.	·923	...	60·0
(Imp. Inst.) No. 2	·903	...	74·0
Ceylon. (Imp. Inst.)	·894	...	71·0
Saigon. (Schimmel's Rept. 1906, p. 45)	·8917 $\frac{15^\circ C.}{15^\circ C.}$	- 0·16°	82·0
West Indian Oil. (Schimmel's Rept. April 1907, p. 68.)	·879	?	75·0

It will be seen that the citral content is capable of varying between wide limits. The specific gravity of West Indian oils varies from ·88 to ·9 at $\frac{15^\circ\ C.}{15^\circ\ C.}$, and the optical rotation is usually about $-0{\cdot}25^\circ$ to $-0{\cdot}3^\circ$.

It has generally been raised as an objection to West Indian oils that they are not completely soluble in alcohol. The average West Indian lemon grass oil is miscible with 95 per cent. alcohol up to one and a half times the volume of oil examined: further addition of alcohol causes turbidity.

It has been found that when examined *immediately upon distillation* West Indian lemon grass oil is completely soluble in 95 per cent. alcohol without turbidity developing as the proportion of alcohol is increased, but a few days later the oil loses this property and will not give clear mixtures with 95 per cent. alcohol if the volume of the alcohol is increased beyond about twice the volume of the oil. It was thought that the substance giving rise to this turbidity might be an acid produced by the partial oxidation of the citral; washing the oil with weak solutions of sodium carbonate and sodium hydrate failed to remove the cause of the turbidity, which is now considered probably to be due to the polymerisation of some hydrocarbon which may be myrcene.

An attempt has recently been made to introduce the Cochin variety of lemon grass (*Cymbopogon flexuosus*), which is stated to yield an oil completely soluble in alcohol: in addition, it is said that the oil from this grass frequently possesses a higher citral content than that of West Indian lemon grass. This grass is now growing well at several of the Botanic Stations in the Leeward Islands. Small trial distillations have resulted as follows:—

Source of oil.	Specific gravity.	Optical rotation in 100-mm. tube.	Citral. Per cent.
1. From Cochin grass grown at Botanic Station, Antigua	·8910 at $\frac{28^\circ\ C.}{16{\cdot}6^\circ\ C.}$	$-0{\cdot}86^\circ$	63·0
2. From Cochin grass grown at Botanic Station, Antigua	·8899 at $\frac{27^\circ\ C.}{16{\cdot}6^\circ\ C.}$	$-0{\cdot}69$	64·0
3. From Cochin grass grown at Botanic Station, Montserrat	·8922 at $\frac{27{\cdot}5^\circ\ C.}{16{\cdot}6^\circ\ C.}$	?	53·0
4. From Cochin grass grown at Botanic Station, Montserrat	·8935 at $\frac{27^\circ\ C.}{16{\cdot}6^\circ\ C.}$	?	68·0

These oils from Cochin lemon grass are completely soluble in alcohol.

So far these oils do not appear to possess a citral content greatly in excess of oil from West Indian grass, but, as the citral content of the latter oil varies considerably according to the condition of the grass when cut, it may be that the Cochin grass has not yet been examined under the best conditions. That mature grass gives oil with a higher citral content than young grass, is shown by the following.

An experiment was performed in which equal weights of two lots of grass of different age were distilled : the yields were noted and the oils analytically examined side by side.

The results were as follows :—

	Young grass two to three months old.	Old grass one year old.
Oil from 160 lb. grass or 72·5 kilos.	4·9 fluid oz. (139 c.c.)	7·25 fluid oz. (206 c.c.)
Optical rotation	$-0{\cdot}26°$	$-0{\cdot}42°$
Specific gravity at $\frac{31° C.}{16{\cdot}0° C.}$	0·8669	0·8668
Citral	58·0 per cent.	69·0 per cent.

Further experiments are necessary in order to demonstrate the best age at which to cut, but it would seem desirable that the grass should be cut at a time when there is as little young grass as possible, as for example, during a dry period when growth is not active.

So far our experiments appear to demonstrate that cultivators of this grass should use the Cochin variety, of which the Botanic Stations in the Leeward Islands can supply small quantities for planting.

Experiments at the Botanic Stations appear to indicate that the yield of grass is in the region of 6,000 to 8,000 lb. of grass per acre, per cut.

The number of cuts per year would vary from two to three.

The yield of oil as determined at the Botanic Station is about ·2 to ·25 per cent. of the weight of the grass taken.

Actual figures obtained at the Botanic Station are as follows:—

Acres planted.	Grass reaped. Pounds.	Oil obtained. Pounds.
(Scott's Hill) $\frac{1}{5}$ acre. 1905-6.	1,196	...
(Scott's Hill) $\frac{1}{10}$ acre. 1907.	836	1·26
(Skerrett's) $\frac{1}{10}$ acre.	765	1·41

It may be mentioned that these extractions were obtained during the earlier operations with the still; further experience in working has resulted in improved manipulation and better yields.

Thus seven later distillations have resulted in the obtaining of 3·6 lb. of oil from 1,384 lb. of grass = ·26 per cent. of oil.

The grass upon which these later experiments were performed was obtained from the re-afforestation plot, the area of which is about $4\frac{1}{2}$ acres, but only a portion of the grass has been reaped.

It may be mentioned that the results closely agree with those cited by Mr. Herbert Wright as having been obtained with the crop at Peradeniya and elsewhere in Ceylon.

There, with two cuts in the year, 13,344 lb. of grass were obtained in 1904 from 1 acre, and this yielded 26 lb. of oil.

In his book on cacao, Mr. Wright states that on the average an acre yields 14,000 lb. of grass and 20 lb. of oil.

The yield of oil appears to vary with season. According to Wright, lemon grass gives the same yield at 2,000 feet elevations as at low levels in the Central Provinces of Ceylon.

The crop requires but little cultivation. It is exceedingly hardy, and once established, appears to require little or no attention. Once the land has been cleared, and grass established, no further expense need be incurred until the time of reaping, as the grass appears, by its growth, to keep down weeds.

MANURIAL VALUE.

According to analyses of Ceylon grass by Bruce, it contains:—

Nitrogen...	·12 per cent.
Phosphoric acid (P_2O_5) ...	·09 „ „
Potash	·065 „ „

VALUE OF LEMON GRASS OIL ON THE MARKET.

In 1904-6 prices for Ceylon and Java grass oil ranged from 4*d.* to 8*d.* per oz. in London. A West Indian grass oil from Montserrat was valued in 1904 at $4\frac{1}{2}$*d.* per oz.

Recently, however, high prices have so stimulated the cultivation of the crop in Ceylon and Java as to cause a drop in the market owing to over-production. In April 1907, the price was quoted by Messrs. Schimmel & Co. at 3*d.* per oz., and it was stated that there was no immediate prospect of improvement in prices, a prediction which is borne out as the following extract from Messrs. Schimmel & Co's Annual Report, October 1907, p. 58, shows:—

'Lemon grass oil. As we anticipate, the backward movement of the prices has, since April of this year, made further progress, and the quotations have declined to $2\frac{1}{2}$*d.* per oz. As large contracts had been made at 3*d.* per oz. (as already mentioned by us), there was very little inclination to buy when the market gave way further, and the consequence was a renewed fall. The following figures show in how striking a manner the production has increased in the season 1906-7:—

'Between July 1, 1906, and June 30, 1907, there were shipped:—

To London	...	$609\frac{1}{12}$	cases
" Havre	...	$1,267\frac{5}{6}$	"
" Marseilles	...	$1,733\frac{1}{2}$	"
" Antwerp	...	$129\frac{2}{3}$	"
" Hamburg	...	$1,923\frac{1}{2}$	"
" New York	...	351	"
" Asiatic ports	...	225	"
Total	...	$6,239\frac{7}{12}$	cases
against	...	$2,259\frac{5}{12}$	" in the same period 1905-6
and	...	$1,881\frac{1}{2}$	cases in the same period 1904-5.'

At 3*d.* per oz., a yield of 26 lb. of oil per acre per annum would, therefore, give a return of £5 4*s.* per acre, and at $2\frac{1}{2}$*d.* per oz., £4 6*s.* 6*d.* per acre. It remains to be ascertained whether the oil will be in regular demand at these prices.

Doubtless the position of West Indian oil on the market would be greatly strengthened if lots offered for sale were accompanied by a certificate from a Government Laboratory stating the citral content.

Confusion exists as to the botanical identity of the grasses growing in the West Indies yielding lemon grass oil: from the researches of Dr. Otto Stapf. (*Kew Bulletin*, No. 8, 1906, XLVI) we conclude that the lemon grass commonly grown in the West Indies is *Cymbopogon citratus* and the Cochin grass is *Cymbopogon flexuosus*.

BAY OIL.

In the *West Indian Bulletin* (Vol. IV, pp. 119 and 189), there appears an article dealing largely with questions concerning the botanical identity of the various forms of bay tree met with in the West Indies. The true 'Bay' tree, from which the oil used in making bay rum is obtained, is *Pimenta acris.* A variety yielding from its leaves an oil with a lemon-like odour mingled with that of Bay is described as *P. acris*, var. *citrifolia* (*West Indian Bulletin*, Vol. IV, p. 194). It is to be noted that the term 'Cinnamon' is frequently employed in the vernacular for these Pimentas.

In order to make clear the facts connected with bay oil and its distillation, it is necessary to have reference to its composition. According to Gildmeister and Hoffmann (*Essential Oils*, p. 512), the chief constituents of bay oil are as follows. The arrangement indicates the order of the amounts present :—

1. Eugenol ($C_{10}H_{12}O_2$)
2. Myrcene ($C_{10}H_{16}$)
3. Chavicol ($C_9H_{10}O$)
4. Methyl Eugenol ($C_{11}H_{14}O_2$)
5. Methyl Chavicol ($C_{10}H_{12}O$)
6. Phellanderene ($C_{10}H_{16}$)
7. Citral ($C_{10}H_{16}O$)

Of these by far the most important are eugenol * and myrcene.

The general average physical and chemical characters of normal bay oil are as follows :—

Specific gravity	0·965 to 0·985 at 15° C.
Optical rotation in 100 mm.-tube	up to −2°
Phenol content	59 to 65 per cent. by volume.

The freshly distilled oil is usually pale yellow in colour, becoming brown on exposure to air. When freshly distilled, the oil is completely soluble in all proportions in 90 per cent. alcohol, but on keeping it ceases to be completely soluble owing to the polymerisation of myrcene.

Bay oil is produced by the distillation with steam of the leaves of the bay tree (*Pimenta acris*). A part of the commercial supply is derived from oil distilled in the West Indies, the remainder is distilled in Europe and America from leaves imported for the purpose from the West Indies. A considerable proportion of the West Indian oil is prepared by persons imperfectly acquainted with the properties of essential oils and with the principles involved in their distillation. For that reason it appears probable that imperfectly prepared oils often find their way to market.

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* Eugenol is a phenol, namely allyl-guiacol. Its boiling point is 232°C. under a pressure of 749 mm. Specific gravity at 14·5°C =1·072, and its refractive index at 20° C.=1·5439. On oxidation it gives vanillin and vanillic acid.

Myrcene is an open chain hydrocarbon, one of the so-called olefine terpenes. Its boiling point is 67·7 under 20 mm. pressure. Specific gravity, ·8023 at 15°C., refractive index=1·4673. It is very susceptible to change and polymerizes somewhat rapidly to a thick oil.

During the progress of the distillation of bay leaves the oil obtained varies progressively in composition; in the earlier stages the product consists of the lighter, more volatile constituents, largely myrcene. At first the oil obtained is lighter than water, from which it readily separates and floats on the surface; a point is soon arrived at when the oil has the same specific gravity as water, from which it separates with difficulty; later on an oil is obtained which is heavier than water and subsides in that liquid. The heavier portions of the oil are relatively rich in phenols.

These oils are soluble in one another and the manner in which they are seen by the distiller, depends on the arrangement on the apparatus. It may be that the distillate in falling through the layer of light oil floating on the water in the receiver, yields up the heavier oil which is absorbed by the lighter. Should, however, the receiver be changed at a critical moment, there may be no light oil present to aid the separation of that oil which has about the same gravity as water, and it may flow away with the waste water. The same remarks apply to that portion of the distillate which is perceptibly heavier than water. It may be retained by the lighter oil or it may settle to the bottom of the receiver: in the latter case it may escape the observation of the distiller and may be thrown away.

In order to ascertain the course of events during distillation, and also to ascertain the character and quantity of the oil yielded by mature leaves and young leaves respectively, experimental distillations were undertaken, on two different samples of old and of young leaves from Montserrat. In the first instance the receiver was changed when heavy oil was found to be coming over and an attempt was made to collect the light and heavy oil separately. The discrimination between light and heavy oil, for reasons given above, was not very perfect. Much importance is not, therefore, to be attached to the relative quantities obtained.

The results of the distillations were:—

Old leaves, 70 lb. or 31·75 kilos. yielded 17½ fluid oz. or 496 c. c. of oil. Of this, 460 c. c. were light oil, and 36 c. c. heavy, that is 8 of heavy oil to 100 of light.

Young leaves, 29 lb. or 13·15 kilos. yielded 6 fluid oz. or 171·5 c. c. of oil; of this, 148 c. c. were light oil, and 23·5 c. c. were heavy, that is 17 of heavy oil to 100 of light.

Portions of the light and heavy oils were mixed, in the proportions in which they were collected, to obtain a sample of normal oils. These are referred to below as mixed oils.

In distilling the second lot of leaves no attempt was made to keep separate the heavy and light oils; these were mixed when the distillation was finished. (See 7 and 8 in table.)

The principal characters of the oils are given below :—

	Sp. Gr. at $\frac{30^\circ C.}{15^\circ C.}$	Sp. Gr. at $\frac{15^\circ C.}{15^\circ C.}$	Phenol content per cent. by volume.	Pounds of oil from 100 lb. leaves.
1. Heavy oil from old leaves ...	1·0312	1·0484	93·0	...
2. Light oil from old leaves ...	·9410	·9563	56·5	..
3. Heavy oil from young leaves ...	...	...	86·0	...
4. Light oil from young leaves ...	·9394	·9553	53·0	...
5. Mixed oil from old leaves ..	·9480	·9612	61·0	1·50
6. Mixed oil from young leaves ...	·9507	·9648	60·0	1·27
7. Oil from old leaves	·9505	at $\frac{28^\circ C.}{16{\cdot}6^\circ C.}$	60·5	1·10
8. Oil from young leaves	·9308		53·0	1·12

In all cases the mixed or normal oils were too dark to permit of the optical rotation being observed.

Occasionally one meets with West Indian bay oils which differ in a marked degree from the normal oils here described; these oils are generally pale in colour, have a low specific gravity, and a low phenol content, while in optical activity they show a somewhat high laevo-rotation.

Three samples examined in this laboratory had the following characters:—

No. and date.	Specific gravity.	Optical rotation in 100-mm. tube.	Phenol content.
1. 24.4.01 ...	·8785 at $\frac{26{\cdot}7^\circ C.}{26{\cdot}7^\circ C.}$	$-5{\cdot}4^\circ$	?
2. 2.03 ...	·8855 at $\frac{15{\cdot}5^\circ C.}{15{\cdot}5^\circ C.}$	$-2{\cdot}3^\circ$	25 per cent.
3. 7.1.05 ...	·8955 at $\frac{15^\circ C.}{15^\circ C.}$	$-5{\cdot}23^\circ$	29 per cent.

Samples 2 and 3 were examined for kerosene, but none was found. These samples are believed to represent unskilfully prepared West Indian oils, in the preparation of which the heavy oil had been overlooked and lost by the distiller.

Messrs. Schimmel & Co., in their Semi-annual Report for October 1902, p. 13, give the following characters of low grade oils :—

No.	Specific gravity at $\frac{15^\circ \text{ C.}}{15^\circ \text{ C.}}$	Optical rotation in 100-mm. tube.	Phenol content.
1.	·8705	$-2^\circ\ 3'$	23 per cent.
2.	·8787	$-2^\circ\ 13'$	about 24 „ „
3.	·873	$-2^\circ\ 14'$	about 24 „ „
4.	·8704	$-2^\circ\ 3'$	20 „ „
5.	·8753	$-3^\circ\ 23'$	33·5 „ „
6.	·8619	$-2^\circ\ 14'$	18 „ „

The report states that all these oils were adulterated with small amounts of petroleum.

While it is true that low grade oils of the kind here described, may be the outcome of want of skill in their preparation, the suspicion of deliberate fraud is not absent in some cases. There is a demand for what are known as 'extra strong' oils, that is, heavy oils with a high phenol content. Such oils may be obtained by separating the light and heavy oils during the process of distillation, or they may be prepared by distilling off the light oil from oil already distilled, thus leaving a heavy residue rich in phenols.

To demonstrate the possibility of the last-named course, 100 c. c. of normal bay oil were distilled under reduced pressure (460 mm.), with the following results :—

1st fraction	65° - 75° C.	5 c.c.	Consisted of equal parts of water and colourless light oil.
2nd „	75 - 170° C.	38 c.c.	Colourless light oil the bulk of which distilled at 165° C.
Residue above	170° C.	57 c.c.	Dark, heavy oil.

Fraction 2 had a specific gravity of ·8402 at $\frac{31^\circ \text{ C.}}{16 \cdot 6^\circ \text{C.}}$, an optical rotation of $-4 \cdot 51^\circ$, and a phenol content of 16·0 per cent.

The residue had a specific gravity of 1·0215 at $\frac{29 \cdot 5^\circ \text{C.}}{16 \cdot 6^\circ \text{C.}}$, and a phenol content of 88·0 per cent.

LEMON-SCENTED BAY OIL.

As already mentioned, there exists a variety of bay tree yielding an oil having a lemon-like odour.

The two varieties of bay, namely the ordinary bay (*P. acris*), and the lemon-scented bay (*P. acris*, var. *citrifolia*), occur together in Dominica, Montserrat, Barbuda, and Antigua, while Mr. Fishlock, the Agricultural Instructor in the Virgin Islands states, that while the ordinary bay is the form commonly met with in the island of St. John, the lemon-scented variety is that found in Tortola, very few trees of the ordinary type being met with in the latter island.

Very little is known regarding the properties of this variety of bay oil. The tree producing it resembles the true *P. acris* in appearance but differs markedly from it in odour of the essential oil.

The first mention of it which we have been able to discover is by Hart (*West Indian Bulletin*, Vol. III, p. 172, and Vol. IV, p. 189). In this latter reference the results of a chemical examination of Hart's oil are quoted as follows:—'The oil has a light yellow colour and strong lemon-like odour; its specific gravity is 0·882 at 25° C., and its optical rotation is 0·37° at 27° C. in a 100-mm. tube.'

The citral content of a sample of Hart's oil was determined in this laboratory to be 65 per cent. by the bisulphite method.

Recently we have succeeded in obtaining a sample of lemon-scented bay leaves from Tortola and a trial distillation has been conducted thereon.

As a result 15 lb. of leaves yielded 2·71 fluid oz. of oil or 1·11 per cent.

The oil was of a pale lemon-yellow colour and had a strong lemon-like odour accompanied by a peculiar secondary after-odour resembling that of Phenyl isocyanide.

Chemical examination of the oil resulted as follows:

Sp. Gr. $\frac{27\ \text{C.}}{16{\cdot}6\ \text{C.}} = {\cdot}8937$ D. $-\ 0{\cdot}16^{\circ}$

Citral content, 44 per cent.; Phenol, 10 per cent.

The oil is completely soluble in alcohol of all strengths down to 60 per cent.

Contrary to the statement in the *West Indian Bulletin* (Vol. VI, p 192), that *P. acris* does not grow well on the limestone soils of Antigua, it is now ascertained that these trees are to be found there in fair numbers.

CAMPHOR AND CAMPHOR OIL.

A small quantity of wood, and of leaves and twigs from the camphor trees growing in the Botanic Gardens at Dominica have recently been submitted to distillation.

In one experiment 90 lb. of camphor wood gave 7·1 fluid oz. of oil, and in two separate experiments with leaves and twigs, on

one occasion 33 lb. of leaves and twigs gave $2\frac{3}{4}$ fluid oz. of oil, and in a second 29 lb. gave 6·2 fluid oz. The small yield in the first of the two distillations with leaves and twigs is accounted for by the fact that in the first case the condensation arrangements adopted were not very satisfactory and considerable loss occurred therefrom.

The oils were found on examination to possess the following properties:—

Oil from camphor wood.—

Sp. Gr. $\frac{27^{\circ}C.}{16\cdot6^{\circ}C.} = \cdot9012$ D. $-13\cdot1^{\circ}$

Oil from leaves and twigs, 1st distillation.—

Sp. Gr. $\frac{27\ C.}{16\cdot6\ C.} = \cdot9024$ D. $-18\cdot4^{\circ}$

Oil from leaves and twigs, 2nd distillation.—

Sp. Gr. $\frac{27\ C.}{16\cdot6\ C.} = \cdot8987$ D. $-19\cdot0^{\circ}$

The oils were all clear and colourless and no solid camphor was obtained.

It is somewhat remarkable that no solid camphor was obtained, nor could any be obtained by cooling the oil. The high laevo-rotation of the oil precludes the presence in it of any appreciable quantity of camphor which had not separated out. In this connexion it is interesting to note that the British Consul Playfair, in a report on the Trade of Foochow for the year 1906 (*Diplomatic and Consular Report* No. 3,913 p. 12) writes:—

'It is said of the existing trees that a considerable number do not produce camphor. Some theorists assert that, like the cocoa-nut palm, *Cinnamomum Camphora* grows to perfection only close to the sea. Others, that camphor trees are male and female, and that crystals of the desired quality are found in the male only. This theory is, however, scientifically inexact, since the flower of *Cinnamomum* is polygamous.'

STILLS.

For the distillation of essential oils from such materials as lemon grass, bay leaves, and the like, very simple forms of apparatus will suffice. All that is necessary is to have the means of passing a current of steam through the material to be distilled, confined in a chamber, and so arranged that the steam may pass away into a suitable condenser provided with a receiver.

Experiments have been made with a very simple form of still as shown in the following diagram. A large cylindrical iron drum about $4\frac{1}{2}$ feet by 2 feet 4 inches has a perforated grating fixed within, at about 10 inches from the bottom; an iron lid fits upon a flange at the top and is so arranged that it can be made steam-tight by packing. The drum is mounted over a small furnace or fire-place. From the side of the drum, very near to

DIAGRAM I.

STILL FOR ESSENTIAL OILS

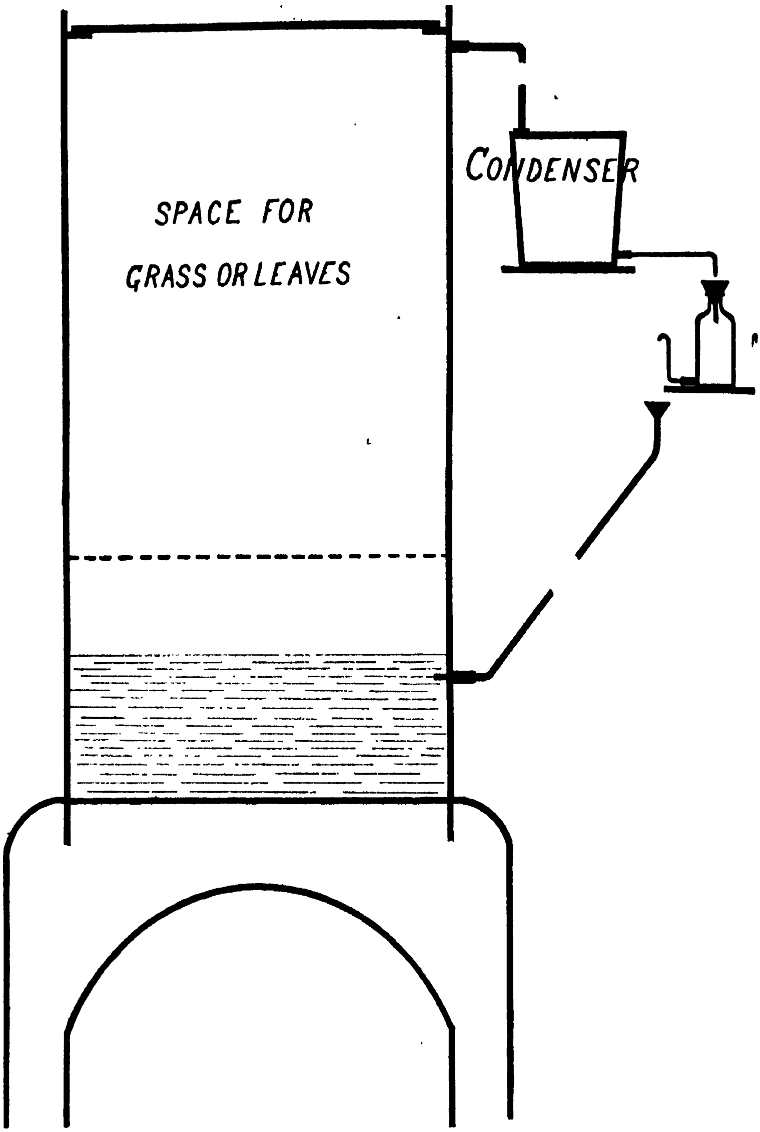
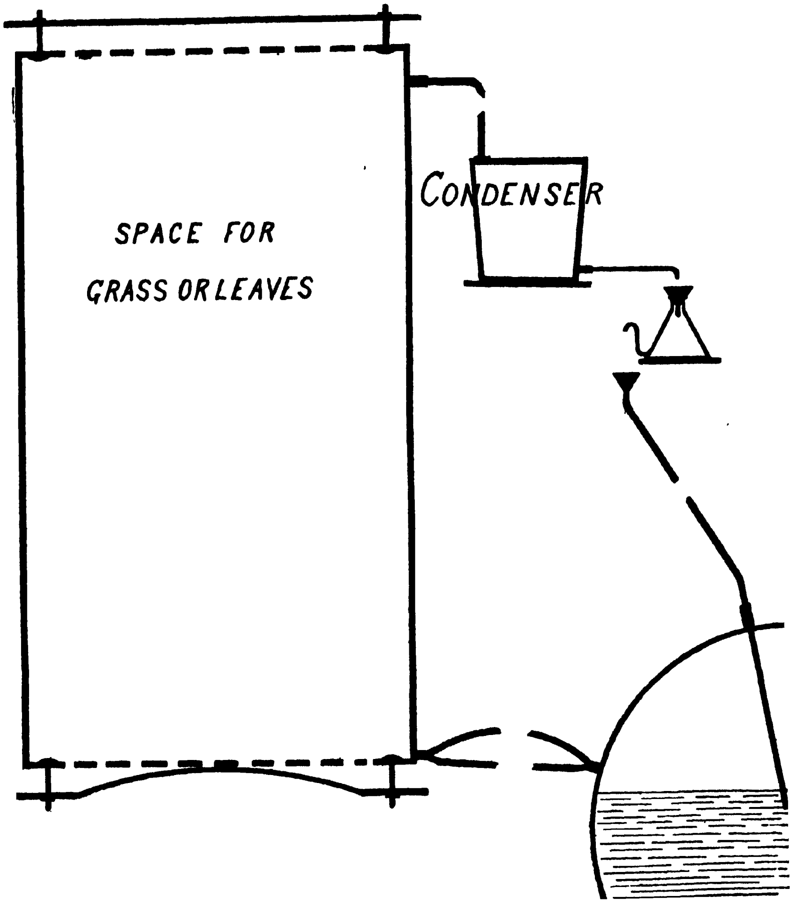


DIAGRAM II.

STILL FOR ESSENTIAL OILS.



the top, a pipe is provided for carrying the steam and products of distillation to the condenser, which is a simple 'worm-tube' through which a current of cold water can circulate.

Water is placed in the bottom of the drum below the grating, the grass or other material to be distilled is placed above the grating, the lid is tightly closed, and if necessary, weighted, and distillation conducted by placing a fire beneath the drum.

By placing the condenser at a sufficient elevation, and by using as a receiver, the well-known form of Florentine flask for effecting the separation of the oil from the water, it is easy to arrange matters so that the condensed water may return directly to the still, as shown in Diagram 1. This arrangement has several advantages : it reduces the amount of water necessary, it obviates the danger of the still being injured owing to all the water being boiled away with the consequent burning of the still, while it has the great advantage of returning to the still any oil which may inadvertently escape with the waste water, and permitting its recovery by redistillation. This latter point is of considerable importance when distilling bay oil.

The defect of this type of still is that it is inconvenient to discharge the contents when the distillation is finished. This difficulty may be got over by generating steam in a separate boiler and so arranging matters that the drum containing the grass or leaves can be opened both at top and bottom, thus permitting it to be charged from the top and discharged from the bottom. Diagram 2 will make this clear. It is suggested that the drum may be placed horizontally, though probably the vertical position is preferable.

The drum may be made of galvanised sheet iron. It is calculated that a drum 4 feet in diameter and 6 feet long will hold about 400 lb. of lemon grass at a charge.

A NOTE ON COCHIN LEMON GRASS OIL.

BY PROFESSOR J. P. D'ALBUQUERQUE, M.A., F.I.C., F.C.S.,
Analytical Chemist and Island Professor of
Chemistry, Barbados.

The two specimens of Cochin lemon grass oil exhibited on the table before the Conference were prepared as follows:—

The grass, grown in Barbados, was reduced to a fine state of subdivision by passing through a disintegrating apparatus. It was then placed with water in an ordinary copper still. The contents of the still were boiled and a current of steam was passed in from an auxiliary still. The steam charged with oil was conducted through the tin worm of an ordinary condenser, and the resulting liquid collected in a glass receiver. In the receiver the oil separates and floats on the surface of the water: the water was partly syphoned off and partly separated in a separating funnel. The last traces of water were removed by drying the oil over calcium chloride. Specimen No. 1, prepared as above, contains, so far as we are able to determine by published analytical methods, a high content of citral. Specimen No. 2 was obtained from some of No. 1 by redistilling in vacuo, and is lighter in colour and clearer.

The yield of oil was small, but this may be attributed to the fact that the grass was over-ripe when cut; also, our appliance being not large enough, the extraction extended over some weeks, and there was evident loss during storage of the grass.

VEGETABLE IVORY.

BY H. A. ALFORD NICHOLLS, C.M.G., M.D., F.L.S.,

President of the Dominica Agricultural and Commercial Society.

The plant which bears the seeds known as vegetable ivory is named botanically *Phytelephas macrocarpa*, and it has been placed in an order, of which it is the chief representative, called the Phytelephantinae. It differs from the palms only in its flowers, which have an indefinite number of stamens; but some botanists—considering this characteristic insufficient to constitute a natural order—have made the Phytelephantinae a division of the Palmeae.

The tree is indigenous to Panama, Columbia, and New Granada, and it has received several colloquial names, the chief of which is the vegetable ivory palm. In those Spanish American countries in which it mostly abounds, the natives call it *Marfil Vejetal.*

The tree has a thick, rough, creeping trunk, from the under surface of which roots are given off. The leaves, which crown the stem, closely resemble in their size, shape, and disposition, those of the cocoa-nut palm. The male and female flowers are borne on different trees, and the trunk of a male plant is always taller and more erect than that of a female.

The inflorescence of the male plant is a simple, fleshy, cylindrical spadix, about 4 feet long, with four or five spathes, and crowded with flowers, while that of the female plant, which also forms a simple but much shorter spadix bears from six to seven flowers, pure white in colour.

The flowers exhale a powerful perfume, and this is more especially the case with the large white female flowers, which are, however, few in number. The ripe fruit consists of three portions: an external one which is dark, rough, hard, and woody; a middle one that occurs as an oily pulp of a yellow colour and sweet taste; and an inner portion—the seed—which is the vegetable ivory of commerce. The oily pulp is collected at the right season, and sold under the name of *Pipa de Jagua* in New Granada, while the seeds are exported for use, as their name implies, as a substitute for ivory. The fruits grow from the stem just above the bases of the leaves, and they occur in aggregations of six or seven. The natives of Columbia call these collections of fruits *Jagua*, or *Cabeza de Negro*, on account, no doubt, of their resemblance in size and shape to a negro's head. Each fruit contains from six to nine seeds, so that in one collection or bunch of fruits there may be as many as sixty seeds, or ivory nuts, as they are commonly called. The seeds have a rough crust, of a dark-brown or slate colour, enclosing the white albumen which at one end surrounds the small embryo. The albumen, or the so-called ivory, is of a dull opalescent colour, but it becomes whiter and more opaque by exposure to the light and air. It is softer and less brittle than ivory, and it is therefore much used as a substitute for the

more costly tusk of the elephant. By chemical analysis the albumen of the seed has been found to consist of a combination of cellulose, gum, caseine, oil, and albumen, with some residual ash.

The tree was first seen by the Spanish botanists Ruiz and Pavon in the groves of the hotter parts of the Peruvian Andes, and it was described by them under the name *Phytelephas macrocarpa*. The following extracts from the memoranda of these botanists is of interest:—

'The Indians cover their cottages with the leaves of this most beautiful palm. The fruit at first contains a clear insipid fluid, by which travellers allay their thirst: afterwards this same liquor becomes milky and sweet, and it changes its taste by degrees as it acquires solidity, till at last it is almost as hard as ivory. The liquor contained in the young fruits becomes acid if they are cut from the tree and kept some time. From the kernels the Indians fashion the knobs of walking-sticks, the reels of spindles, and little toys, which are whiter than ivory; and so hard, if they are not put under water—and if they are, they become white and hard again when dried. Bears devour the young fruit with avidity.'

The tree, as far as I know, is not cultivated to any extent, the seeds being gathered by the natives from plants in a wild state. Large quantities of vegetable ivory are obtained from the banks of the River Magdalena, and are exported from Panama to the home markets.

When a vegetable product is gathered from plants not under cultivation, the supply, from a variety of causes, must of necessity be fluctuating; and, moreover, the sources of supply are in constant danger of being exhausted, as was the case when cinchona bark was alone obtained from the forests of the Andes. There can be no question, therefore, of the advisability of tropical agriculturists turning their attention to the cultivation of the vegetable ivory plant, as they have already done in the case of other economical trees. The constant increase in consumption of the article points to the success of such an undertaking.

In Jamaica, in Trinidad, and in Dominica, the plant would thrive along the banks of the rivers and streams which run through many of the estates, and thus a profitable crop might be obtained from land which is now principally occupied by scrub or a jungle of reeds. Trees grown at St. Aroment, Dominica, were grown from seed sent from Panama. The seeds germinated readily and the plants were hardy and they have grown at the edge of a small stream—which sometimes runs dry—without any care or cultivation. In suitable situations therefore, they can look after themselves; so that, beyond the original small expenditure in raising the plants and setting them out, nothing else is required; and, in these circumstances, a plantation of ivory nut palms should be a very profitable property.

A POPULAR ACCOUNT OF THE GEOLOGICAL FORMATION OF BARBADOS.*

BY PROFESSOR HARRISON, C.M.G., M.A., F.I.C., F.C.S., F.G.S., F.G.S.A.,

Director of Science and Agriculture, British Guiana.

In the Scotland district of Barbados which is now before us, we have to an extent that I believe is not equalled in any other part of the world, a very remarkable and complete series of strata, which contains representatives of the various abyssal deposits now accumulating at the bottoms of the oceans. It will be of interest, standing where we do now, to trace in some detail the history and the relationships of these Oceanic beds to the other strata of the island. We can from this spot readily see representatives of the different formations of which the island is composed.

The oldest beds are seen to the west of where we stand at Belle Hill, near St. Andrew's Church, to the south-east, in the lower parts of Chalky Mount, and to the south-west at Mount All. We do not know with any certainty their geological age, as they have hitherto yielded few, if any, fossils; but from analogy with similar beds which are found in Trinidad, we regard them as being probably Cretaceous or Eocene-cretaceous: that is, they are geologically either equivalent to the English chalks or are of somewhat more recent origin.

You will notice that they are marked by great flexures, and, in the part of Chalky Mount we have just passed, that the curves are exceedingly abrupt, so that in some places the strata are reversed. They consist mainly of argillaceous sandstones interspersed with beds of hard, coarse, siliceous grits, and of gravelly conglomerates, and are traversed by partings of shaly clays containing bands of ironstone and of septarian concretions. Among the beds are some relatively narrow ones of limestone. These abruptly folded beds have a general north-eastly and south-westly strike. Many of the beds contain flakes of white mica—muscovite—in very varying proportions. Their composition shows us clearly and unmistakably, that they were formed close to a land area; this may have been the then north-easterly extremity of the continent of South America. In fact geologically we may regard Barbados as the extreme north-easterly part of South America; Tobago and Trinidad serving as connecting links between Barbados and that continent.

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* This brief account was given by Professor Harrison, during the excursion of the Conference Delegates to Bathsheba and Belleplaine.

Like many of the rocks of the Guianas, the grits and gravelly conglomerates are more or less auriferous. The conglomerates consist of more or less angular pebbles of quartz, with some of felspar, the latter in places showing the structure of plagioclase. They, like the rocks composing the great sandstone plateaus of the Guianas, have been derived from the detrition of granitic rocks. I have examined specimens of the grits and have found them to yield to fire-assay about 1 dwt. of gold to the ton of rock. The value of that amount of gold is represented by $1·00, but it would probably cost from $8·00 to $10·00 to extract it.

There was a tradition of the early settlers in this island that the gravels and sands of the Scotland river, near to where we are standing, were auriferous, and I believe that attempts were made at washing them for gold, but without success. Yellow grains that people have from time to time mistaken for gold were obtained in places in the island. These, however, consisted of iron pyrites—so-called fool's gold—and their occurrence was regarded as explanatory of the early settlers' tradition. But since I left Barbados the river gravels have been panned by competent prospectors, friends of my own, who easily obtained 'colours' of gold, but the 'prospects' were only such as warned them from further search in the Scotland river for payable deposits of gold.

The remarkable contortions we notice in these sandstones and conglomerates are characteristic of the oldest beds in the island, and are not shared by any of the younger strata. They are the results of the gradual sinking of the island to very great depths, with consequent compression that crumpled and folded up the strata by the effects of the tangential strains set up during their depression.

The next chapter, or possibly volume, of the geological history of the island is missing. We notice that to the south-west of where we stand, the sandstones are succeeded by a great thickness of strata, consisting mainly of brown bituminous sands and sandy clays, some of the beds of which are very rich in petroleum. These petroliferous strata lie unconformably on the highly contorted sandstones and grits, and form broad folds, the general strike of which is east and west. White mica is of relatively rare occurrence in the petroliferous beds. These beds are shallow marine or estuarine beds formed near to some great land-surface, but probably in greater depths of water than that in which the Eocene-cretaceous strata were deposited. They are rich in places in organic debris, now largely converted into petroleum. The thickness of the petroleum-bearing beds varies from 400 to perhaps as much as 700 feet. The upper beds of this series are argillaceous, and they were evidently deposited in water of greater depth than the lower ones were.

A few fossils have been obtained from the petroliferous strata, and doubtless, if careful search were made, many others would be found. Those found are all of Oligocene facies, and therefore, the petroliferous deposits are of the same age and of

like origin as the bituminiferous strata near San Fernando in Trinidad.

Again, a chapter or a series of chapters of the geological history of Barbados is missing, but the succeeding records show us that great changes in this region had taken place during that time. Those white marls and chalks which you see to the north-west of this place at Cleland Hill, and at Pico Teneriffe, supply us with proofs of this. The shallow water deposits on which we stand were depressed to very great depths, to possibly 10,000 or 12,000 feet below the surface of the ocean, and probably to even greater depths. This change was doubtless accompanied by crumpling, folding, and fracture. Great cracks were formed in places, and in these fissures, petroleum, forced from time to time from the petroliferous sands, gradually accumulated. In course of time it became inspissated and lost its more volatile constituents, and thus the fissures were lined and filled with asphaltum or 'manjak.' These masses of asphaltum are true fissure-veins, and not unfrequently a vein traverses various strata.

The abyssal or Oceanic beds—the next phase in the history of the island—form its most remarkable feature. We will follow their record in some detail.

From where we stand, the nearest exposures of the abyssal strata are on the upper parts of Chalky Mount east of us, at Bissex Hill to the south-west, at Swanns to the west, at Cleland to the north-west, and at Pico Teneriffe in a more northerly direction.

In each of these places the lowest beds are highly calcareous. On Bissex Hill and at Cleland, they are bluish-white or white limestones, whilst in the other places they form hard, fairly compact, grey to white chalk. These basal beds contain from about 60 to nearly 90 per cent. of calcium carbonate, and they are principally made up of foraminifera and their residua. The foraminifera mainly belong to about fifty species of *Textularia*, *Lagena*, *Nodosaria*, *Cristellaria*, *Globigerina*, *Pulvinulina*, and others, and many of them are characteristic of deep-sea oozes. In each place, commencing at a few feet above the base, we find that the strata are traversed, at short intervals apart, by beds usually thin but of very varying thickness, which strongly resemble fine-textured brown to greyish sands. Microscopical and chemical examinations show them to consist of wind-borne volcanic dust. Here we have indisputable records of numerous eruptions having taken place, presumably in Miocene times, from volcanoes situated in what is now the Caribbean region. And it is worthy of note, that the compositions of many of these dust-beds are comparable with those of the volcanic dusts which fell in Barbados in 1812, 1902, and 1903.

Beds of volcanic dust occur at short intervals all through the oceanic deposits and are characteristic of these strata in Barbados. I have not recognized any beds of volcanic debris in the older underlying Cretaceous and Oligocene strata or in the overlying Coraline ones. But this may be due to these being

strata which were deposited in wave-and current-disturbed, shallow water, so that any volcanic dust which may have fallen on them would be widely distributed throughout them, and would not occur in thin seams as they do where they were deposited at the bottom of the calm, almost motionless, depths of the ocean.

The calcareous strata at the base of the Oceanic beds strikingly resemble modern foraminiferal oozes. They are not very thick, and when followed upwards are seen to become less calcareous and more siliceous: the foraminiferal organisms in them gradually becoming less abundant, their places being taken by siliceous ones belonging principally to the radiolaria. These foraminiferal-radiolarian beds contain from 46 to about 73 per cent. of calcium carbonate, doubtless derived from calcareous marine organisms, and from 14 to about 22 per cent. of colloid silica in the form of organisms such as radiolarians, sponge-spicules, etc. At Mount Hillaby where the succession of the Oceanic beds is possibly most clearly seen, the chalks and foraminiferal-radiolarian beds are about 40 feet in thickness. They are succeeded by about 130 feet of siliceous beds, of which the remains of siliceous organisms make up from 50 to about 80 per cent. of their total weight, whilst the proportion of calcium carbonate varies from about 0·5 to about 2·5 per cent.

Now these strata bear a very complete resemblance, both in chemical composition and in their contained organisms, to those only found in the greatest depths of the oceans. They are comparable with the radiolarian oozes found by the 'Challenger' expedition in the deepest parts of the abyssal depths of the Pacific Ocean. We are justified in concluding, that when these beds were being deposited, the strata on which we now stand were depressed so as to be at depths of from 18,000 to 24,000 feet below the surface of the ocean.

Above these are beds of about 50 feet in thickness, in which the proportions of calcium carbonate steadily increase, and those of the siliceous organisms decrease as we pass upwards. These beds yield from 25 to over 30 per cent. of the former, and from 42 to about 25 per cent. of the latter. They contain many layers of volcanic dust, occurring at short intervals. Above these are some 25 feet of white chalks, with a few beds of volcanic dust, which are very similar both in chemical composition and in their contained organisms to the beds at the base of the oceanic deposits.

The organisms in the oceanic deposits of Barbados, especially the siliceous radiolaria, form most beautiful objects for examination under the microscope. In this part of the geological history of the island are clear records of a gradual descent of the strata to abyssal depths, and of, in turn, a slow reversal of this process, with, in addition, records of many recurring outbreaks of volcanic activity. It is worthy of notice, that the beds of volcanic dust are far more in evidence in the middle and southern exposures of the Oceanic beds, than in the more northerly ones.

Above the upper chalks at Mount Hillaby, and generally in the central districts of the island, are beds of very fine-grained, soft, argillaceous earths of varying colours—red, pink, brown, yellow, and creamy white or mottled. Where fully exposed, as they are at Mount Hillaby, they are about 60 feet thick. The earths are nearly free from the remains of organisms, but here and there in them are the siliceous spicules of a sponge, or the remains of a radiolarian or of a diatom; they are free from calcareous organisms, although occasionally a trace of a foraminiferal cast may be detected. In character and in composition they have a close resemblance to many of the red clays, which were found by the 'Challenger' to cover vast areas of the floors of the ocean.

These complete the series of deposits characteristic of Barbados with which we answered, in 1891 and 1892, the challenge thrown down to geologists some years before, after the publication of the earlier reports of the 'Challenger' Expedition, to produce true deep-sea deposits which had been raised above the sea-level. That series, as it lies before you on the older beds, supplies the fullest proofs which have yet been adduced, that portions of the continental area have been depressed to oceanic depths and later re-elevated.

To make the proofs still more complete, Professor Gregory supplied the case of an echinoderm—a sea-egg—that was found in a well at Haynesfield in the upper parts of the siliceous beds. That sea-egg—determined by Gregory as *Cystechinus crassus*—proved to be an example of one of the most typical species of deep-sea echinoids, and one which has never been found above the 1,000-fathom line, its records being 1,050, 1,900, and 1,915 fathoms.

Next we will consider the concluding part of that chapter of the geological record which deals with the oceanic deposits. As far as I am aware, this part is only seen at Mount Hillaby. Above the beds of red and mottled clays there are there about 25 feet of grey-coloured volcanic mudstones. Here, then, we have evidence of an outbreak of volcanic activity far in excess of any of those recorded in the older parts of the Oceanic series. The mudstones are deposits of fine volcanic dust closely resembling those which have fallen on Barbados in late years, and show very clear evidence that the dust which gave rise to them was erupted at a distance from Barbados, and was wind-borne. The falls of felspathic and pumiceous dust sank through the water and mingled with the oozes which were then accumulating on the ocean-floor. Possibly the thick deposits of argillaceous materials at the higher parts of the Oceanic series were derived from volcanic material and are closely related to the intensification of the volcanic activity which characterized the period during which the oceanic strata were accumulating, and we may regard its conclusion as marked thereby.

Although there are, in Barbados, these very clearly marked evidences of great volcanic activity at some distance, probably to the west and north-west of it, there is no evidence whatever, as far as I have been able to ascertain, of the former existence

of a volcano or even of volcanic rocks in the island. Then, as now, Barbados was only troubled by occasional falls of wind-borne volcanic dust derived from eruptions of the volcanoes which mark that great line of earth-weakness along the fringe of the Caribbean Sea.

At and near Chalky Mount, we found the earliest records of the geological history of the island. To get another and later chapter therein, we must pass in imagination for about 2 miles south of it to Bissex Hill. Here we get another remarkable chapter dovetailed in by a series of faults among the records of the true Oceanic period.

The lowest of the strata of the Bissex Hill series are whitish foraminiferal marls exceedingly rich in calcareous organisms, of which some 120 species have been described. The greater part of the organisms consists of *Globigerina*, and among the other kinds of foraminifera present, Miocene and Older Pliocene species are strongly in evidence. The beds contain numerous recent forms, and these indicate that the Globigerina marls of Bissex Hill were laid down probably at depths of about 1,000 fathoms. Thus this new chapter in the record commences, as did the record of the true Oceanic beds, at a considerable depth. The lowest beds of the Bissex series are more or less detrital in nature and contain many rolled pebbles and small lumps of the beds of the Oceanic series with possibly some material derived from still older beds. These are succeeded by a series of yellowish to buff-coloured marls, which contain great numbers of large, very thick-shelled Globigerina. Ascending the series the number of foraminifera other than Globigerina rapidly increases, and specimens of *Ehrenbegina*, *Nodosaria*, *Textularia*, *Miliolina*, *Bigenerina*, and *Cristellaria*, together with some other forms, become common. The higher parts of the hill consist of Globigerina marls and limestones which contain many fragments of the oceanic chalks. In the uppermost of the limestones Globigerina gradually die out whilst other foraminifera (especially *Amphisteginae*) increase in abundance, and fragments of molluscan shells are commonly present.

Spines or plates of echinoderms are generally found in both the lowest and uppermost beds at Bissex Hill, but they are very irregularly distributed. Possibly the abundance of the remains of echinoderms point to some of the then inhabitants of the locality having similar tastes as regards sea-eggs to those which now characterize many of the inhabitants of Barbados.

Few perfect echinoderms have been found at Bissex Hill; the best preserved specimen found was named by Professor Gregory, *Archaeopneustes abruptus*.

Casts of small turbinate corals occur in the limestone, which have a deep-water facies. Throughout the beds great numbers of sharks' teeth belonging to *Carcharodon*, *Hemipristis*, *Oxyrhina*, and *Lamna* are found. May not their owners have used the sea-eggs in their dietary? Or have we here a record of some pre-historic painless dentist? In the

upper beds many nullipores, notably *Lithothamnium*, and numerous millepores occur.

The *Globigerinae* gradually disappear from the upper strata of the limestones and *Amphisteginae* become so common, that in places the rocks are almost wholly made up of them.

The *Amphistegina* limestones in turn pass through basal reef-rocks to true coral-rocks.

In several other places in addition to Bissex Hill, evidence has been obtained of the former existence of *Globigerina* beds, but no traces of them have been found on the highest parts of the island or at Mount Hillaby, at Chimborazo and at Castle Grant, which are the places where the highest members of the Oceanic beds are found. This indicates that the Bissex beds were laid down during a period in the elevation of Barbados before any part of it became an island, when the central part of the uplift was within the influence of currents, strong enough to prevent deposition and to cause some erosion of the soft Oceanic beds which formed the surface of the rising dome or ridge. Small indurated lumps of these beds on the sea-floor eventually rolled down the outer slopes and were embedded in the dense accumulation of foraminifera which was being formed round their borders.

The sequence of the beds on Bissex Hill shows that, after a time, the introduction of this detritus became less frequent, and that a nearly pure *Globigerina*-marl was formed. Later again the elevatory movement was renewed and the depth of the water diminished more and more: molluscs, echinoderms, and other organisms contributed their debris to the deposits, and currents once more rolled along small pebbles and fragments of the older rocks. Ultimately the central dome came within the limits of coral growth, and an island was formed, which was continually added to, partly by successive elevations, partly by the outward growth of the foraminiferal and coral debris deposits, and this process of building up is indicated at Bissex Hill by the sequence of *Amphistegina*-rock, of basal reef-rock, and of rock full of corals.

We have now traced the history of the parts of the island in the neighbourhood of where we are standing from the continental conditions indicated in the lowest Cretaceous and Oligocene strata, through their oceanic phase to the commencement of the record of a coral-built island.

The later history of the island is not well seen from where we stand, but we can notice on the western side of the ridge of high ground at Mount Misery, Mount Hillaby, Chimborazo, and Castle Grant, that the limestones which were deposited on the slowly rising dome of the island gradually changed from foraminiferal limestones to reef-rocks, and thence to true coral-rock; and we see the escarpment which extends from near Mount Stepney in the north-east to near Codrington in the south-east of the district we have visited to-day, which probably represents some of the earliest parts of the reef and oral-rocks formed on the ascending island.

It has been suggested by some observers, that the isolated blocks of limestone, which you have noticed in several places where we have been to-day, lying on the older strata, are remnants of a coating of limestone which once extended over this Scotland district of Barbados. But I doubt if this is the case. As you are all aware, corals cannot flourish in muddy water, and it is probable that the sea on the eastern side of the island was, as it is now, subject to heavy floods of muddy rain-water rushing from the exposed beds of the lower strata. It is, I think, to this that the freedom of the Scotland district from a former widespread capping of coralline limestone is due.

If we examined the western slopes of Barbados as we have done its eastern ones, we should find ample evidence of several stages in the gradual upheaval of the island. These stages are marked by successive terraces, each of which indicates a period of pause and of coast erosion during the construction of the island. On the eastern side I have found evidences of similar terraces; towards its south-east and north-east parts they exist as actual terraces of relatively thin reef-rock, whilst in the districts near where we stand, they are indicated only by isolated blocks of limestone or by raised beach-deposits. I detected, I believe, seven or eight of these terraces or raised beaches ranging from the terraces at present in course of formation near Codrington, at Bath, and below Bathsheba, to those at levels at about 700 feet to the east of the great escarpment between Hackleton's Cliff and St. John's Church.

Upon examination, the isolated limestone rocks in this district are found more generally to consist of *Amphistegina*-limestone than of true coral, and hence are not coral-reef rocks. This is in accordance with our theory, that during the gradual evolution of the island this part of it was not covered by a protective coating of limestone, but was exposed to denudation and detrition, which carved out its present striking features of rugged hills and wide valleys, acute ridges and steep-sided ravines.

I have attempted, in the course of half an hour or so, to read from the book of nature as exposed before you, some of the details of the Geological History of Barbados. But it is not possible to describe in a few minutes, changes which occupied probably several millions of the years of the world's existence.

There is a series of papers published between 1891 and 1907 in the *Quarterly Journal of the Geological Society*, in which Professor Gregory, Messrs. Jukes-Browne and Franks, endeavoured to elucidate some phases of the evolution of Barbados, and to extend the knowledge of its geological structure and history found in the admirable account of its coral-rocks written by Schomburgk about 1848, and given in the little brochure on the Geology of Barbados issued by the Government of Barbados in 1890, as an explanation of the geological map of Barbados prepared by Messrs. Jukes-Browne and myself, and drawn for us by my wife.

There is still much to be discovered in connexion with the geology of Barbados, and there are several disputed points to

be cleared up. Quite recently, a widely known geologist seeing some inclined (in my opinion false-bedded) strata, which I will point out to you as we pass through Consett's railway cutting, on our way back to Bridgetown, made a new theory of the evolution of the island, which, if correct in all respects, would place the lower parts of the limestone escarpments you see before us, under the white chalk and marls which are below them, and would degrade the limestones to a geological level with the bituminiferous strata. This theory requires Mount Misery at the head of St. Andrew's valley to be somewhat over 15,000 feet in elevation. But Mr. J. R. Bovell and I last year visited a place whence the scientist in question stated he had obtained irrefutable evidence of the accuracy of his contentions, and there we found masses of *Colpophyllia gyrosa*, and of *Orbicellaa acropora*, which served in place of the historic lump of 'old red sandstone' whilst endeavouring to settle the dispute.

Accurate determinations of the sequences of the various strata underlying the oceanic deposits, and studies in detail of the petroliferous strata, especially in connexion with their possible occurrence below the limestone capping in the south-western parts of the island, are greatly to be desired; whilst collections of the corals found in the limestone terraces at various elevations, and of the fossils of the formation in the Scotland district, would be of high scientific value.

AGRICULTURAL EDUCATION.

PRACTICAL INSTRUCTION OF OVERSEERS.

DISCUSSION.

Dr. FRANCIS WATTS (Leeward Islands) brought forward a suggestion that something might be done, through the Imperial Department of Agriculture, to organize a system of scientific and practical instruction of overseers, and sub-managers of estates, to be followed by examination for certificates of proficiency.

Courses of reading suitable for young men anxious to extend their knowledge of matters relating to tropical agriculture should be established. These courses should have special reference to the methods of cultivation of local crops.

The examinations, he suggested, should be held at regular intervals, and candidates might, if they wished it, be examined in a single branch of knowledge, such as the methods of cultivation, etc., of a particular crop. The examinations should be broad and general in their scope, and certificates of proficiency should only be awarded as the result of general practical knowledge.

No one should be allowed to sit for examination unless he had been engaged in actual practice on an estate for at least one year, in order that it might be assured that he should be thoroughly qualified in the practical cultivation of the crops specified upon his certificate of proficiency. The examinations should be as practical as possible, and the board of examiners should contain at least one or two practical planters.

In conclusion, Dr. Watts referred to how diplomas or certificates of proficiency might be of value in the guidance of owners and attorneys of plantations towards the choice of men for junior posts, and stated his conviction that, when these courses were generally established throughout the West India Islands, young men holding certificates would be much more likely to obtain increased remuneration than under present conditions.

Professor P. CARMODY (Trinidad) in supporting the scheme, said they had had some experience in Trinidad in connexion with the Victoria Institute in dealing with the education of people who were employed during the day. They had succeeded to a considerable extent in commercial subjects, and were trying also in connexion with agriculture. The question of local certificates, however, had been their chief trouble. Certificates of some kind were necessary to be given as the result of annual examinations so as to satisfy both the

teachers and pupils as to the results. They had come to the conclusion that a local certificate carried no weight with the employer of men, and eventually they found that the London Board of Commerce issued certificates of proficiency in various trades, which were recognized all over the British Empire, and which almost exactly suited the requirements in Trinidad. He thought that similar certificates would be found practical for carrying out Dr. Watts' scheme.

Perhaps the Royal Agricultural Society would undertake to issue diplomas or certificates of efficiency. But there would be some difficulty to be overcome in the matter of examinations. Examination questions would have to be set by examiners in the West Indies.

Certain subjects should be selected for study, and to avoid cramming, the examination should be held in two parts with an interval of one year or more between each; and candidates should be required to specialize, taking one industry for a given period and another at another period and so on.

Mr. J. H. HART (Trinidad) could speak on this subject with some knowledge, because forty-one years ago he passed a similar examination as that referred to by Professor Carmody, and for that examination he had to do a considerable amount of reading, which had been of the greatest use to him in after life. Subjects were set, text-books were given the candidates, and they had to pass the examinations of the Society of Arts, South Kensington, on which a certificate was issued.

Mr. J. R. BOVELL (Barbados) said that in view of the want which existed in Barbados in this connexion, he most heartily supported the scheme brought forward by Dr. Watts. Some time ago a junior Assistant was wanted in the local Agricultural Department, but difficulty was experienced in obtaining a man with sufficient general knowledge to fill the post. He thought that a system of reading courses and examinations on the lines indicated by Dr. Watts would be of great advantage to the people in Barbados.

Professor J. B. HARRISON (British Guiana) was in favour of the scheme, but thought that considerable difficulties would arise from the divers conditions existing in the West Indies.

The PRESIDENT remarked that it must be distinctly understood that each colony would have to deal with its own conditions.

Mr. A. D. C. ADAMSON (St. Kitt's) said that while the scheme might be a good thing in its way, and be practicable in the larger colonies, he did not think it would lead to any beneficial results in the smaller islands.

Hon. E. G. BENNETT (St. Lucia) thought that a scheme such as that proposed by Dr. Watts would be of infinite value to the West Indies.

The PRESIDENT suggested that this subject should be brought up for discussion at the various Agricultural Societies in the West Indies, in order that the planters and overseers might be made acquainted with the proposals.

Proposals for such a scheme of Reading Courses and Examinations in Practical Agriculture were immediately outlined by the Imperial Department of Agriculture and were brought before a meeting of the Barbados Agricultural Society, held on January 21, by the Imperial Commissioner of Agriculture, who went over the points outlined above, and suggested that a special meeting of that Society be held for the purpose of considering whether such courses and examinations could be started in Barbados and elsewhere. The Imperial Commissioner pointed out that the agricultural industries of the West Indies would reap considerable benefit from increased scientific knowledge on the part of overseers and managers, and further, that the possession of certificates of competency might also be a means of helping some of the young men of the island to lucrative posts in this and in other colonies.

After consultation with Dr. Watts (Antigua), and Professor d'Albuquerque (Barbados), and other agricultural officers in the West Indies, definite proposals were laid before a special meeting of the Barbados Agricultural Society, held on February 14, by the Imperial Commissioner of Agriculture. The Society unanimously adopted the following resolution :—

'That in the opinion of the Barbados General Agricultural Society, it is desirable that there should be a Course of Reading and instruction in Agriculture for overseers, followed by an examination in the subjects studied, and certificates given on the results of such examinations.'

A committee of the Agricultural Society to co-operate with the Imperial Department of Agriculture was appointed to carry out the terms of the above resolution, and to assist in elaborating the details of the proposed Reading Courses.

The advisability of commencing the same scheme of education for overseers in the Leeward Islands was brought before a meeting of the Agricultural and Commercial Society of Antigua, held on February 28. The following resolution was unanimously passed by the Society :—

'That this Society ask the Imperial Department of Agriculture for the West Indies to institute examinations for the benefit of planters, and to take steps to work out the necessary details, and to issue a syllabus.'

Dr. Watts brought this scheme before a meeting of the St. Kitt's Agricultural and Commercial Society held on July 2, and the following resolution was adopted :—

'That in the opinion of the St. Kitt's Agricultural and Commercial Society, it is desirable that there should be a Course of Reading for overseers on the lines as laid down by Dr. Watts in his address, followed by an examination in the subjects studied, and certificates given on the results of such examinations.

'And that the Imperial Department of Agriculture be requested to undertake the preparation and inauguration of the scheme.'

The details of the scheme were prepared by the Imperial Department of Agricultural, and a large number of leaflets

and circulars were distributed in Barbados, and the Leeward Islands.

Later, the scheme was brought forward in the different islands of the Windward group and has been unanimously endorsed by the Agricultural Societies of Grenada, St. Vincent, and St. Lucia. It also received the support of the respective Governments of these colonies.

COURSES OF READING AND EXAMINATIONS.

Definite courses of reading in agricultural subjects have been designed for Barbados, the Leeward, and the Windward Islands for the purpose of affording persons engaged in practical agricultural pursuits an opportunity of improving themselves as agriculturists. These are to be followed by examinations for Certificates of Proficiency, which, it is hoped, may be the means of helping some to obtain more lucrative posts in the different colonies.

The examinations are as follows: Preliminary, Intermediate, and Final.

The Preliminary is confined to questions on the general elementary principles underlying agricultural practice and can be taken, in some cases, on leaving school, prior to taking up actual work on an estate: or it can be taken simultaneously and in conjunction with the Intermediate Examination. Persons who have passed the Cambridge Senior Examination in Agricultural Science are excused the Preliminary Examination and can at once proceed with the reading for the Intermediate

The Intermediate Examination is more particularly concerned with the practical consideration of the growth and cultivation of two or more specified crops, for proficiency in which the candidate offers himself for examination. This examination cannot be taken until the candidate shall have been employed in the practice of agriculture on an estate for a period of at least one year.

In the Final Examination the subjects taken up in the Preliminary and Intermediate Examinations will be dealt with more fully, and a considerably more extensive knowledge of the treatment and handling of the crops selected in the Intermediate Examination will be looked for by the examiners. In addition, the candidates are expected to be fully conversant with questions affecting estate management and administration.

The first part of each examination will be written and the second part will be oral. No candidate will be allowed to obtain a certificate without thoroughly satisfying the examiners in both parts of the examination.

Certificates signed by the examiners, will be issued to successful candidates by the Imperial Department of Agriculture, and will be countersigned by the Imperial Commissioner. They will be divided into three classes, and will be endorsed with the statement of the subjects in which candidates have shown themselves proficient.

SYLLABUS.

Preliminary Examination.

THE ELEMENTS OF THE PRINCIPLES OF AGRICULTURE.

The atmosphere and the gases composing it. Water and its properties. The chemical and physical properties of sand, clay, chalk, and humus. The classification of soils. The functions of plant food and water. Drainage of soils. The construction and use of one form of plough, of subsoiler, and of cultivator. Tillage and its effects. The preparations and properties of farmyard manure and its chief constituents. The properties and application of sulphate of ammonia, nitrate of soda, sulphate of potash, nitrate of potash, superphosphate, basic slag phosphate, bone meal, guano, quick lime, and slaked lime. Green dressings.

Seeds and their germination. The naked eye structure and outlines of the microscopic structure of the root, stem, leaf, and flower of a plant. Assimilation, transpiration, and respiration in plants. Plant food. The absorption and movement of water in plants. Propagation of plants by cuttings, by grafting and budding. Fertilization. Leguminous plants and nitrification.

The structure and functions of farm animals. Foods and feeding.

Reading.—Fream's 'Elements of Agriculture,' pp. 1-110, and pp. 334-86.

Johnson's 'Catechism of Agricultural Chemistry.'

'Lectures to Sugar Planters.' Imperial Department of Agriculture. Lectures 1-4.

Cousin's 'Chemistry of the Garden.'

'Nature Teaching.' Imperial Department of Agriculture.

Intermediate Examination.

FUNGI, INSECTS, AND SPECIAL CROPS.

The general characters of fungi. Fungoid diseases in plants. The methods of treating fungoid diseases.

The general life-history of insects. The principal orders of insects. The relation of insects to plants. The general treatment of insect pests.

Reading.—Imperial Department of Agriculture Pamphlets.

No. 5.—'General Treatment of Insect Pests.'

„ 7.—'Scale Insects of the Lesser Antilles. Part I.

„ 22.—'Scale Insects of the Lesser Antilles Part II.

„ 17.—'General Treatment of Fungoid Pests.'

„ 29.—'Lectures on Diseases of the Sugar-cane.'

'Lectures to Sugar Planters.' Lectures 3-7.

Fream's 'Elements of Agriculture,' pp. 312-33.

In addition to the above, candidates will offer for examination any two, at least, of the special crops given below. The selection of the crops to be offered will be optional. but candidates must have had practical experience in the cultivation of the crop submitted:—

(1) **Sugar.** The preparation and care of the soil. Planting, manuring, tending, and reaping the crop. The principal varieties of sugar-cane and their characteristics. The principal fungoid and insect pests of sugar-cane and the means used in controlling them. The manufacture of sugar.

RUM. Elementary knowledge of the theory of fermentation and the life-history of yeasts. The changes which take place in the fermenting vats and the manner of observing them. Stills, their structure and use. The use of Sykes' hydrometer, and of spirit 'bubbles.' The colouring of rum. Obscuration.

Reading.—Noel Deerr's 'Sugar and the Sugar-cane.'

Watts' 'Introductory Manual for Sugar Growers.'

'Lectures to Sugar Planters.' Imperial Department of Agriculture.

Candidates may elect to be examined in connexion with the manufacture of sugar by the vacuum pan process, or by the muscovado process, or both, and the section in which they are proficient will be stated on their certificates. The questions on Rum will be optional.

(2) **Cotton.** Preparation of the soil; planting and tending the growing crops; a knowledge of the principal insect and fungoid pests of cotton and the means used in controlling them. Picking cotton. The selection of cotton seed and its preparation for sowing. An elementary knowledge of the qualities of cotton lint and the manner of ascertaining them. The uses of cotton seed.

Reading.—Imperial Department of Agriculture Pamphlet No. 45.—'A B C of Cotton Planting.'

(3) **Limes.** The planting and tending of lime orchards. The chief pests attacking limes and the methods of controlling them. Gathering the crop. Crushing the fruit. The methods of dealing with lime juice. The preparation of concentrated juice and citrate of lime. The preparation of essential oils of limes. The preparation and packing of lime fruit for shipment.

Reading.—Imperial Department of Agriculture Pamphlet No. 53.—'A B C of Lime Cultivation.'

(4) **Cacao.** The planting and tending of cacao orchards. The chief pests attacking cacao and the methods of controlling them. The gathering of the crop. 'The fermentation and preparation of the cacao beans for the market.

Reading.—Hart's 'Cacao.'

Wright's 'Cacao, its Botany, Cultivation, Chemistry, and Diseases.'

(5) **Bananas.** The planting and tending of banana fields. The chief pests attacking bananas and the methods of controlling them. The gathering, handling, packing, and shipping of the fruit.

Reading.—'The Banana Industry in Jamaica.' *West Indian Bulletin*, Vol. III, No. 2.

(6) **Rice.** Cultivation and preparation.

Reading.—'Rice Growing in British Guiana.' *West Indian Bulletin* Vol. II, No. 4.

(7) **Provision Crops.**

Reading.—Nicholls' 'Tropical Agriculture.' Those portions dealing with Maize, Guinea corn, Cassava, Arrowroot, Yam, Potato, and Tania.

Final Examination.

The principles of Agriculture as set out in the syllabus, for the Preliminary Examination, treated more fully; and including: The origin, formation, and composition of soils. The biology of soils. The implements, methods, and effects of tillage. Manures and manuring. Farmyard manures. Green dressings. Liming, etc. Rotation of crops. Haymaking. Ensilage. Improvement of plants by artificial selection and hybridization. The management of farm animals. Special crops: Any two of those mentioned in the intermediate syllabus, but treated now fully.

Candidates must show an accurate knowledge of estate book-keeping, of the cost of performing various operations in husbandry, together with a knowledge of the principal facts governing estate expenditure. They must be familiar with the management of labourers, with the apportionment of, and payment for, work done. They will be required to answer questions concerning the general elementary principles of estate management, including the management of land, crops, labourers, and farm animals, and to show an elementary knowledge concerning the management and care of buildings and implements generally.

Candidates will be expected to be familiar with the work and results of the local Experiment Stations and the reports and papers emanating therefrom.

Reading.—All books previously mentioned.

Hall's 'Soil.'

THE TIMBERS OF JAMAICA.

BY W. HARRIS, F.L.S.,

Superintendent of Hope, Hill, and Castleton Gardens, Jamaica.

To the casual observer who travels over the railway, or the excellent system of roads that intersect the island, it would appear that Jamaica possesses little timber of any value. And this is true of settled districts where more or less extensive clearings have been made for cultivation or for pastures.

The woodlands of Jamaica are not confined to any particular parts of the island; in each parish except certain portions, such as fertile plains and valleys, and suitable grazing lands, we find woodlands occupying rather extensive areas, the total at present being estimated by the Surveyor General at 400,000 to 500,000 acres, or about one-sixth of the island. This estimate, however, does not include scrub-lands.

If it were not for the clearings that are continually being made, the island would be thickly wooded, even on the south side with its scanty rainfall. The vegetation on Goat Island, which lies a few miles south-east of Old Harbour, is proof of this. Goat Island has an area of about 600 acres; it is composed largely of honey-combed rock, with no fresh water, and with a rainfall of probably not more than 30 inches per annum; it is densely covered with vegetation, including a great many trees of all sizes up to 50 or 60 feet in height.

In cleared districts the trees that usually meet the eye are grown, or allowed to grow for the fruit they produce, for the shade they give in pastures, or for ornament; with occasionally a sprinkling of the timbers peculiar to the district.

Whilst many of our trees, requiring certain climatic conditions for their successful growth, are confined to comparatively limited areas in a few districts, others appear to be able to adapt themselves to circumstances, and to thrive equally well in all districts from the coast up to about 3,000 feet altitude. There are, nevertheless, three fairly well defined types of woodland. The savannahs and hills near the coast with a rainfall of about 30 to 50 inches per annum produce principally the following: *Acacia tortuosa*; akee (*Blighia sapida*); bastard cedar (*Guazuma tomentosa*); braziletto (*Peltophorum Linnaei*); button-wood (*Conocarpus erectus*); calabash (*Crescentia Cujete*); cashaw (*Prosopis juliflora*); cashew (*Anacardium occidentale*); clammy cherry (*Cordia Collococca*); cocoa-nut (*Cocos nucifera*); divi-divi (*Caesalpinia coriaria*); dog-wood (*Piscidia Erythrina*); ebony (*Brya Ebenus*); fustic (*Chlorophora tinctoria*); ginep (*Melicocca bijuga*); gru-gru palm (*Acrocomia lasiospatha*); guango (*Pithecolobium Saman*); hog plum (*Spondias lutea*); Indian tulip tree (*Thespesia populnea*); lancewood, black (*Bocagea virgata*); lignum-vitae (*Guaiacum officinale*); locust (*Hymenaea Courbaril*); log-wood (*Haematoxylon campechianum*); mahogany (*Swietenia Mahagoni*); mango (*Mangifera indica*); mangrove, black (*Avicennia nitida*); naseberry (*Achras Sapota*); nickel (*Ormosia monosperma*); park-nut (*Acacia macracantha*); pigeon-wood (*Diospyros tetrasperma*); prickly yellow (*Zanthoxylum martinicense*); satin-wood (*Zanthoxylum flava*); silk cotton tree (*Eriodendron anfractuosum*); scarlet cordia (*Cordia Sebestena*); sea-side grape (*Coccoloba uvifera*); star apple (*Chrysophyllum Cainito*); sumac (*Rhus Metopium*); tamarind (*Tamarindus indica*); torch-wood or flambeau (*Tecoma stans*); West Indian birch (*Bursera gummifera*); white wood (*Tecoma leucoxylon*); *Tecoma platyantha*; wild cinnamon (*Canella alba*); woman's tongue (*Albizzia Lebbek*); yellow candlewood (*Cassia emarginata*); yoke-wood (*Catalpa longissima*).

The middle region and interior hills up to 3,500 feet altitude, rainfall from 70 to 90 inches per annum, produce principally: Bastard cabbage bark (*Andira inermis*): bitter dan (*Simaruba glauca*); bitter wood (*Picraena excelsa*): blind-eye or yucco (*Sapium cuneatum*); blood-wood, or iron-wood (*Laplacea haematoxylon*): boxwood (*Vitex umbrosa*): braziletto (*Peltophorum Linnaei*); breadnut (*Brosimum Alicastrum*); broad-leaf (*Terminalia latifolia*); bullet tree, mountain (*Dipholis montana*): cedar, bastard (*Guazuma tomentosa*); cedar, juniper (*Juniperus bermudiana*): cedar, West Indian (*Cedrela odorata*); cogwood (*Zizyphus chloroxylon*); cromanty (*Ratonia apetala*); logwood (*Piscidia Erythrina*); fiddle-wood (*Petitia domingensis*): galimenta (*Dipholis nigra*); greenheart, or break-axe (*Sloanea jamaicensis*); gutter-wood (*Strempeliopsis arborea*): hog gum (*Symphonia globulifera*); horse-wood (*Pithecolobium latifolium*); iron-wood (*Krugiodendron ferreum*); lancewood, black (*Bocagea virgata*); lancewood, white (*Bocagea laurifolia*); mahoe, blue (*Hibiscus elatus*); mahogany (*Swietenia Mahagoni*); maiden plum (*Comocladia integrifolia*); mammee apple (*Mammea americana*); mango (*Mangifera indica*); mosquito-wood (*Mosquitoxylum jamaicense*): mountain guava

(*Psidium montanum*); naseberry bullet-tree (*Mimusops Sideroxylon*); pigeon-wood (*Diospyros tetrasperma*); pimento (*Pimenta officinalis*); prune (*Prunus occidentalis*); ramoon (*Trophis americana*); rosewood (*Drypetes ilicifolia*); Santa Maria (*Calophyllum Calaba*); sapodilla (*Mimusops excisa*); shad-bark (*Pithecolobium Alexandri*, var. *Troyanum*); shad-bark, tamarind (*Pithecolobium Alexandri*, var. *intermedium*); slug-wood (*Beilschmiedia pendula*); soap-berry (*Sapindus Saponaria*); soap-wood (*Clethra tinifolia*); Spanish elm (*Cordia gerascanthoides*); sweet-wood, loblolly (*Ocotea Leucoxylon*); sweet-wood, timber (*Nectandra exaltata*); sweet-wood, yellow (*Nectandra Antillana*); white bullet tree (*Dipholis salicifolia*): wild cassada (*Turpinia occidentalis*); wild orange (*Esenbeckia pentaphylla*); wild tamarind (*Pithecolobium filicifolium*); yacca, St. Ann's (*Podocarpus Purdieana*); yellow sanders (*Buchenavia capitata*); yoke-wood (*Catalpa longissima*); zebra wood, also called satin-wood (*Zanthoxylum caribaeum*).

In the highland region above 3,500 feet altitude, rainfall 90 to 150 inches or over, the following species occur: Alligator wood, or musk wood (*Guarea trichilioides*); blood-wood, or iron-wood (*Laplacea haematoxylon*); fiddle-wood (*Petitia domingensis*); *Ilex obcordata*; juniper cedar (*Juniperus bermudiana*); mountain guava (*Psidium montanum*); soap-wood (*Clethra tinifolia*); wild cassada (*Turpinia occidentalis*); wild juniper (*Lyonia jamaicensis*, and *L. octandra*); yacca (*Podocarpus Urbanii*); mountain zebra-wood (*Eugenia fragrans*).

It may be useful if I now give a short description of each of the principal timber trees of the island as far as I have been able to gather reliable information about them. I do not wish it to be inferred that the following is a complete list: there are a good many useful timbers with an extremely local distribution, but the identification of the species awaits complete botanical material for careful examination, and this material is being got together as opportunities offer.

1. *Acacia tortuosa*, Willd.

A low tree found near the coast. It makes lasting fence posts and is largely used as firewood and for charcoal-making.

2. ALMOND, TROPICAL (*Terminalia Catappa*, Linn.).

An introduced tree but naturalized and common in the lowlands. It grows to a height of 50 feet with a trunk of about 2 feet in diameter. The timber possesses many of the characteristics of mahogany and weighs 58 lb. per cubic foot. It is used for furniture and house work.

3. AKEE (*Blighia sapida*, Koen.)

This is an introduced tree now naturalized and very common at low altitudes. It grows to medium size and yields a timber which is light and durable and suitable for all purposes except in exposed situations.

4. ALIGATOR WOOD, OR MUSK WOOD (*Guarea trichiliodies*, Linn.).

This is a fairly common tree in the woods of the Blue Mountains. All parts of the tree have a strong smell of musk. The wood is used for shingles.

5. BASTARD CABBAGE BARK OR ANGELIN (*Andira inermis*, H.B. & K.).

A common tree in the lower and middle regions. It is a medium-sized tree with a straight trunk up to 30 feet in height, and 1 to 2 feet in diameter. It is a strong, hardy wood, lasting well in water and is, therefore, suitable for piles and bridges, as well as for framing houses, mill rollers, and naves of wheels. The grain is brown and streaky, like cocoa-nut. The weight is 58 ℔. per cubic foot.

6. BASTARD CEDAR (*Guazuma tomentosa*, H.B. & K.).

This is a common tree in open situations up to about 3,000 feet altitude. It is of a spreading habit with a trunk rarely higher than 20 feet and with a diameter at the base of 2 feet. It yields a good timber which is light and splits readily. It is used for all purposes except in exposed situations.

7. BITTER DAN, BITTER DAMSON, STAVEWOOD (*Simaruba glauca*, DC.).

A tree growing to a height of 40 to 50 feet, fairly common at altitudes of 1,500 to 2,000 feet. It is a light wood weighing about 30 ℔. per cubic foot, and is useful for inside work such as partitions. It is said to resist the attacks of wood ants on account of its bitter properties. The wood splits easily, saws with ease, and planes well except across the end of the grain.

8. BLIND-EYE OR YUCCO (*Sapium cuneatum*, Griseb.).

This tree appears to be found only in the western end of the island. It yields a valuable, lasting wood, which is useful for railway sleepers, bridge building, wharf piles, and for general purposes in outside work.

9. BLOOD-WOOD, OR IRON-WOOD (*Laplacea haematoxylon*, G.Don.).

This fine tree is only found at high altitudes. It grows to a height of about 50 feet with a trunk diameter of 1 to 2 feet. It yields a heavy, fine-grained timber, said to be the hardest timber in the West Indies. The wood is of a deep reddish colour, heavy, with dense grain, and will not decay in wet or dry soil. It has much the same qualities as boxwood, and is useful for the same purposes, for posts, and for general purposes in exposed situations.

10. BOXWOOD, OR FIDDLE-WOOD (*Vitex umbrosa*, Sw.).

This is a moderate-sized tree, found in the mountains. Used for framing houses, and for general purposes where a lasting timber is required in exposed situations. It is easily worked up.

11. BRAZILETTO (*Peltophorum Linnaei*, Benth.).

A large tree, often growing to a height of 80 feet with a trunk 4 feet in diameter. It is found in most parts of the island, but it is most abundant in the central and western parishes. The wood is hard and durable, of a bright-red colour. It is used for railway sleepers, spokes of carriages and cart wheels, for ornamental cabinet work, and for general purposes. This is considered one of our best native timbers.

12. BREADFRUIT (*Artocarpus incisa*, Linn.).

Breadfruit plants were first brought to Jamaica from Otaheite by Admiral Bligh in 1791, for which he received a vote of 1,000 guineas from the House of Assembly of Jamaica, and the Gold Medal of the Society of Arts of London. The tree is now very common in districts with an annual rainfall of about 90 to 150 inches. The fruit is an important food product, and the tree furnishes a wood which is pretty when polished, yellowish-grey in colour, rather light and soft, but strong, resistant, and elastic, with a specific gravity of 0·495. It resists the attacks of the white ant and only needs to be kept dry to be fairly durable. It is used principally for cabinet work, but is suited for furniture, boards, and internal house work.

13. BREADNUT (*Brosimum Alicastrum*, Sw.).

A tall, erect tree, up to 100 feet, with a diameter of 2 feet or over. It grows principally on the interior slopes of the northern coast range, and notably on the levels of the hills in St. Catherine, Clarendon, Manchester, and St. Ann. It yields a plentiful supply of nuts which form a valuable fodder, as do also the leaves. The timber is good and makes capital boards, which take a high polish and furnish beautiful flooring. The heartwood has a rich brown colour, with very durable qualities, and is excellently fitted for ornamental work of all kinds.

14. BROAD-LEAF (*Terminalia latifolia*, Sw.).

This tree attains a height of 80 to 100 feet with a trunk diameter of 3 to 4 feet. It is very general on the limestone from 1,500 to 2,000 feet altitude, but not so common at lower elevations. The wood is not thought much of for building purposes, but it splits readily and is used for shingles and barrel staves.

15. BULLET, OR BULLY TREE, MOUNTAIN (*Dipholis montana*, Gr.).

This tree is found all over the island below 3,500 feet altitude. It grows to be a large tree with a trunk up to 4 feet in diameter. It is largely employed in general construction, is durable, and much used for sawing into boards, planks, scantlings, and shingles.

16. BUTTON-WOOD (*Conocarpus erectus*, Linn.).

A small tree along the coast in mangrove swamps. Very useful for posts and piles, being lasting both in and out of ground, and in salt-water.

17. CALABASH (*Crescentia Cujete*, Linn.).

A common tree on the plains and lower hills. It is comparatively small, seldom more than 20 feet high, with a trunk 18 inches to 2 feet in diameter. The wood is hard, tough and pliant, and, being almost black, takes a fine polish. Being of crooked growth it is only employed for small work, such as handles of tools, carriages, cattle yokes, felloes of wheels, etc. The weight is 54 ℔. per cubic foot, and crushing strength 1·42 tons per square inch.

18. CASHAW (*Prosopis juliflora*, DC.).

A tree up to 30 feet high, common in the alluvial deposits along the south coast. The trunk is seldom more than 1 foot in diameter, but occasionally old specimens are seen with trunks measuring up to 2 feet in diameter. It is a very desirable strong timber, and is largely used for fence posts, footing telegraph posts, and such work ; also for railway sleepers, and knees in boats. It is excellent for fuel, both as firewood and as charcoal. The weight of the wood is 61·26 ℔. per cubic foot. The pods when dry, are splendid fodder and are greedily eaten by stock of all kinds. Horses, however, frequently die after eating damp pods, apparently from the germination of the seed in the stomach.

19. CASHEW (*Anacardium occidentale*, Linn.).

This is a fruit tree found commonly on the plains. It grows to a height of about 30 feet with a trunk diameter to 2 feet. The wood is red, moderately hard, and close-grained. and weighs 61 ℔. per cubic foot, with a crushing strength of 3·76 tons per square inch.

20. CEDAR, JUNIPER (*Juniperus bermudiana*, Linn.).

This is one of the three conifers native of Jamaica. It is distributed over a clearly defined area of the Port Royal and Blue Mountains between 3,000 and 6,000 feet altitude. It rarely grows to a height of 40 feet, and usually with a trunk diameter of 1½ to 2 feet, although occasionally in old specimens the trunk measuros up to 4 feet in diameter. It gives a handsome, light, fragant wood, with beautiful graining, and is used for furniture, cabinet work, interior ornamental house work, and, where plentiful, for posts. The tree is not common, having been cut wherever accessible.

21. CEDAR, WEST INDIAN (*Cedrela odorata*, Linn.).

This is our best known native timber tree, found all over the island from 1,000 to 4,000 feet altitude. It attains a height usually of 40 to 60 feet with a trunk diameter of 3 to 4 feet, but in the Cockpit Country in St. James, I have seen specimens over 100 feet in height with trunks up to 8 feet in diameter and buttresses like a *Ceiba*. It is a quick-growing tree, the wood being dark-red or brown, fissile, open-grained, but soft and porous. It is slightly absorbent of water and has a sweet, peculiar fragrance. The wood weighs 36 ℔. per cubic foot with a crushing strength of 2·94 tons per square inch. It is in most

general request for furniture, shingles, interior house work and general carpentry; cigar boxes and ornamental cabinet work. It is most suited for wardrobes, as its odour repels moths and other insects. Cedrela wood-oil is obtained from this tree, and the bark yields a gum resembling gum arabic, got by making incisions.

22. CLAMMY CHERRY (*Cordia Collococca*, Linn.).

A common tree at low elevations. It is of medium height with a spreading head, and is highly ornamental when laden with its translucent scarlet berries. The wood is useful for all purposes except in exposed situations; also suitable for staves and headings of hogsheads and barrels.

23. COCOA-NUT (*Cocos nucifera*, Linn.).

Aged, and unfruitful trees of the well-known cocoa-nut palm are cut down and the wood is turned to a variety of useful purposes. It is strong and heavy, and very handsome when polished, but most hard to work, although when freshly cut it is spongy. When well seasoned it will last for a long time under ground. It weighs 70 lb. per cubic foot, and is adapted for walking sticks, fancy articles, frames, furniture, rafters, and for veneering. Owing to its speckled colour, resembling porcupine quills, it is known in commerce as Porcupine Wood.

24. COGWOOD, OR GREENHEART (*Zizyphus chloroxylon*, Oliv.).

A large tree found throughout the interior hills, though not plentiful, most of the accessible timber having been cut. The wood is dark, close-grained and weighs about 70 lb. per cubic foot. It is used for mill framings, cogs of gear wheels, etc.

25. CRO-CRO (*Tecoma Brittonii*, Urb.).

This is a new species discovered by the writer in the Cockpit Country, Trelawny, in 1904, and subsequently collected in the same country, St. James, in 1905. It has also been detected in the Santa Cruz Mountains. It is a tree up to 40 feet high with a trunk diameter of about 1½ to 2 feet. It furnishes excellent timber, hard and durable, and suitable for general purposes.

26. CROMANTY (*Matayba apetala*, Radlk.).

A fairly common tree in woods of the interior hills. It grows to a height of about 40 to 60 feet with a trunk up to 2½ feet in diameter. It is a most useful hardwood, suitable for all purposes, and especially for exposed situations.

27. DIVI-DIVI (*Caesalpinia coriaria*, Willd.).

A small crooked tree 20 to 30 feet high, found near the coast. The wood is of little value, but the pods are rich in tannin and are used locally and also exported.

28. DOG-WOOD (*Piscidia Erythrina*, Linn.).

A tree 20 to 40 feet high and 2 to 3 feet in diameter of trunk, found on the plains and in the hills up to 3,500 feet altitude. The wood is tough and elastic, and is much used for railway sleepers, wharf piles, felloes of wheels, cart and carriage work, rollers of native sugar mills, and for other work requiring a tough wood. The bark of the root is an intense narcotic.

29. DOWN TREE, OR CORK WOOD (*Ochroma Lagopus*, Sw.).

A tree 20 to 50 feet high, and up to 2 feet in diameter of trunk; found in damp valleys up to about 1,000 feet altitude. The wood is white and softer than ordinary cork, for which it is used as a substitute; also by fishermen as a float for their nets, and for other purposes requiring a very light wood.

30. EBONY OR COCUS WOOD (*Brya Ebenus*, DC.).

A small tree up to 25 feet high, with drooping branches, and a trunk of 6 to 18 inches in diameter. It grows abundantly on the plains and lower hills near the southern coast. It has a hard heart-wood of a rich brown, or almost black colour, very sharply defined from the sulphur-yellow sap-wood, and weighs over 80 lb. per cubic foot. It is used for making walking sticks, flageolets, for inlaying, and for cabinet and turning work generally.

31. FIDDLE-WOOD. (*Petitia domingensis*, Jacq.).

A common tree in the lower, and especially in the interior hills. It grows to a height of 40 to 50 feet, with a trunk about 2 or 2½ feet in diameter. The wood is close-grained and very tough, and is most useful for building, for railway sleepers, and for general purposes where a hard, tough wood is required.

32. FUSTIC (*Chlorophora tinctoria*, Gaud.).

A tree up to 50 feet high and a trunk diameter ranging up to 3 feet. It is generally distributed on the lower hills and up to an altitude of about 2,000 feet. The wood is close-grained, hard, tough, and of a bright canary-yellow colour. It is used for furniture, cabinet work, panels, etc., and is excellent for hubs and felloes of wheels. Its weight is 42 lb. per cubic foot. It is largely exported, chiefly as a yellow dye-wood.

33. GINEP (*Melicocca bijuga*, Linn.).

This is a common fruit tree, found in the plains and lower hills up to about 3,000 feet altitude. It attains a height of 30 to 40 feet with a trunk up to 3 feet in diameter, or larger in very old specimens. The wood is useful for all purposes except in exposed situations.

34. GREENHEART OR BREAK-AXE. (*Sloanea jamaicensis*, Hook.).

A tree from 60 to 100 feet in height and a trunk diameter up to 2 feet, found in the interior limestone hills. It is a very heavy timber, with dense, deep-coloured heart-wood, suitable for any purpose, and especially for exposed situations.

35. GRU-GRU PALM (*Acrocomia lasiospatha*, Mart.).

A common tree on the plains, and up to 1,000 feet altitude. Trunk attains a height of 30 to 50 feet and is protected with circular rings of black spines. The outer part of the trunk is black as ebony, hard, heavy and durable, and susceptible of a high polish. The wood possesses the characteristic of never bending, warping, or curling longitudinally. It furnishes a beautiful veener, and might be used for furniture and cabinet work. It is sometimes run into mouldings, its dark colour forming a fine set-off to a panel of pine, and it likewise makes handsome walking sticks.

36. GUANGO, OR SAMAN (*Pithecolobium Saman*, Benth.).

This is a naturalized species and one of the most handsome trees on the lowlands. It is found near the coast as a rule, but grows to perfection on the alluvial plains of St. Catherine and Clarendon, and in the Plantain Garden River Valley. It is a large spreading tree with a short trunk which attains a diameter of 8 feet or over. The tree is grown principally for shade and for its pods, which are produced in great abundance and are a very nutritious and fattening fodder for stock. The wood is hard and ornamental, but cross-grained and difficult to saw. It is good for all purposes except in exposed situations.

37. GUTTER-WOOD (*Strempeliopsis arborea*, Urb.).

This is a new species, unknown to science until discovered by the writer in the Cockpit Country in 1901. It grows to a height of 40 feet with a trunk diameter of about 2 feet. It furnishes useful timber which lasts well in water.

38. HOG GUM (*Symphonia globulifera*, Linn. f.).

A lofty tree growing to a height of over 100 feet with a trunk diameter up to 6 feet. It grows principally in damp, mountain woods. The timber, which weighs slightly over 50 lb. per cubic foot, is useful for interior house work, and for shingles. It yields a gum which is at first fluid and pellucid, but afterwards changes to a yellow colour and becomes hard and friable, resembling Burgundy pitch. It is used medicinally.

39. HOG PLUM (*Spondias lutea*, Linn.).

A high spreading tree with a trunk up to 3 feet in diameter, common on the lowlands and up to about 1,000 feet altitude. Branches of this tree are used as fence posts, and usually grow when so planted. The wood is light, and is suitable for staves and headings of hogsheads and barrels.

40. HORSE-WOOD (*Pithecolobium latifolium*, Benth.).

A low tree, common along the banks of rivers in the interior. The trunk is seldom more than 1½ feet in diameter, but the wood is hard and durable and suitable for purposes in exposed situations. It makes good fence posts.

41. *Ilex obcordata*, Sw.

Usually a low bush, but forms a tree with a trunk 30 feet high, and 1 to 1½ feet in diameter. It is found only on the highest slope of the Blue Mountains. The wood is hard, heavy and durable.

42. INDIAN TULIP TREE. (*Thespesia populnea*, Soland.).

This is an introduced tree but is common along the sea-coast. It is a moderate-sized evergreen tree. The sap-wood is soft; wood pale reddish, with small, dark-coloured, hard heart-wood. The wood weighs about 50 lb. per cubic foot, and is used in South India for gun stocks, boats, cart and carriage making, and for furniture; and in the Carolinas for bowls, clubs, paddles, and carved work.

43. JACK FRUIT (*Artocarpus integrifolia*, Linn.).

This tree grows to a height of 40 feet, with trunk diameter of over 2 feet. It is an introduced tree but is now plentiful and especially so in the Cockpit Country. The wood which weighs about 40 lb. per cubic foot, is yellow, hard, takes an excellent polish, is beautifully marked and is one of the handsomest furniture woods. In India it is largely used for carpentry, boxes and furniture, and it is exported to Europe for cabinet work, turning, and brush backs.

44. LANCEWOOD, BLACK (*Bocagea virgata*, B. & H.).

An erect tree attaining a height of 30 feet with a trunk diameter of 9 to 12 inches, found in the woods of the central and western parishes. The wood possesses great elasticity, and on that account is exported for making carriage shafts, lances, spars, fishing rods, ramrods, general turnery, etc.

45. LANCEWOOD, WHITE (*Bocagea laurifolia*, B. & H.).

This tree grows to a height of 50 feet or over with a trunk diameter of 12 to 18 inches or more. It is used to some extent but is not nearly so valuable as black lancewood.

46. LIGNUM DORUM (*Ocotea staminea*, Mez.).

A large tree found in the western and northern forests, and interior woodlands of St. Ann and Westmoreland. It grows to a height of 40 feet or over, with a trunk diameter of 2 to 3 feet. The wood is considered excellent for inside work, and for shingles.

47. LIGNUM-VITAE (*Guaiacum officinale*, Linn.).

A low tree up to 20 feet high and with a trunk diameter up to 2½ feet, though usually not more than 18 inches in diameter. It grows only on the lowlands near the coast, but is plentiful. The heart-wood is of a dark, greenish-brown colour, the sap-wood being pale yellow. The wood is exceedingly dense, hard, heavy and tough, weighing 76 lb. per cubic foot. It is extremely useful for sheaves and blocks of pulleys, rulers, skittle balls and other turnery purposes,

It is sometimes used for machine bearings, where its qualities of hardness and durability render it preferable to metal. Its crushing strength is 3·87 tons per square inch.

48. LOCUST TREE (*Hymenaea Courbaril*, Linn.).

A large tree with a spreading head, and a trunk up to 5 feet in diameter. The wood is of a reddish-brown colour, streaked, close-grained, extremely hard and tough. It resembles mahogany, but is much harder and is liable to rot in the ground. It is suitable for cabinet work and furniture, as it takes a fine polish. On account of its freedom from splitting or warping it is well adapted for mill timbers, cogs of wheels, and engine work. Its weight is 59 ℔. per cubic foot, and crushing strength 5·17 tons per square inch.

49. LOCUST-BERRY OR HOG-BERRY (*Brysonima crassifolia*, H.B. & K., var. *jamaicensis*, Urb. & Neid.).

A tree up to 25 or 30 feet high, with a trunk diameter of 1½ to 2 feet. It grows in the interior hills up to 2,500 feet altitude. The wood is useful for general purposes except in exposed situations.

50. LOGWOOD (*Haematoxylon campechianum*, Linn.).

This is a small bush-like tree, seldom more than 20 feet high, with a trunk about 1 to 2 feet in diameter, although there are trees on Goshen Pen, St. Elizabeth, measuring up to 24 feet in girth. The heart-wood is of a dark-red colour, hard, and is used for posts and cabinet work. It is, however, exported solely as a dye-wood. It produces violet and blue colours, shades of gray, and more especially blacks, giving to the latter a velvety lustre.

51. MAHOE, BLUE OR MOUNTAIN (*Hibiscus elatus*, Sw.).

A tree 50 to 80 feet high, and with a trunk diameter of about 3 feet. Very general in damp districts from 500 to 2,000 feet altitude. The wood, which weighs about 47 ℔. per cubic foot, is much used in building, and for shingles, etc. It makes a very pretty flooring, handsome furniture, cabinet work, and picture frames. It is also found to be one of the best native woods for railway sleepers, and is largely used for this purpose. When fully ripe it is of a dark blackish-green colour, with darker or lighter bands, and makes a pleasing contrast with lighter coloured woods. The bark yields an excellent fibre much used for making short lengths of rope and cordage.

52. MAHOE, SEA-SIDE (*Hibiscus tiliaceus*, Linn.).

A small tree 10 to 20 feet high. The wood is less compact than that of Blue Mahoe, and not considered of much value. The bark affords a strong fibre, which is used for ropes and cordage.

53. MAHOGANY (*Swietenia Mahagoni*, Linn.).

The tree, which produces the well-known mahogany timber grows to a large size with a trunk diameter of 6 or 7 feet, but, as generally seen, it is about 30 to 40 feet high and 2 to 4 feet in diameter. It is still fairly plentiful from the shores of Westmoreland and St. Elizabeth, up through the limestone hills and extending into St. James, Trelawny and parts of Manchester: elsewhere it is not so abundant. Jamaica mahogany is very fine, and in the 'great houses' of estates there are many fine specimens of beams and rafters of this wood, very old, but in good condition. There are also to be found in many houses throughout the island very handsome old bedsteads, wardrobes, sideboards, etc., made of this wood. It was also extensively used for interior building work—doors, window frames, staircases, ceilings, etc., of mahogany being quite common in old houses. It is still employed for furniture and ornamental work. Formerly the wood from Jamaica was specially reputed for its mottled grain.

54. MAIDEN PLUM (*Comocladia integrifolia*, Jacq.).

This is a small tree 10 to 30 feet high, but not usually over 6 to 9 inches in diameter. It is found principally in the lower hills and up to 4,000 feet altitude. The wood is very hard, but does not grow large enough for sawing. It makes excellent posts which grow when planted.

55. MAIDEN PLUM (*Comocladia velutina*, Britton.).

This is a new species recently discovered by the writer. It grows to a height of 40 feet, and is altogether a much larger tree than *C. integrifolia*. It is found only at low elevations, e.g., the Healthshire Hills, Goat Island, etc. The wood is said to be hard and durable, but further investigation is necessary before anything definite can be said about it.

56. MAMMEE APPLE (*Mammea americana*, Linn.).

A spreading tree 40 to 60 feet high, generally distributed, though not abundant, from 1,000 to 2,500 feet altitude. The wood is hard and durable, well adapted for house building, posts and piles, and generally for work in exposed situations.

57. MAMMEE SAPOTA (*Calocarpum mammosum*, Pierre.).

Generally distributed, but nowhere plentiful. A stout tree with a dense head; grows to a height of 30 feet with a trunk up to 4 feet in diameter. The timber is first-class and adapted to many uses, especially house construction, both exterior and interior; also furniture, etc.

58. MANGO (*Mangifera indica*, Linn.).

The mango was first brought to Jamaica 120 years ago, and, in its numerous varieties, it is now one of the commonest trees in the island in open places from the sea-coast up to 4,000 feet altitude. It is the favourite fruit of the natives. The tree grows to a height of 30 or 40 feet with a trunk diameter up to 6 feet. It gives a pretty red wood, of inferior

quality, coarse, open-grained and soft. It is durable in dry situations, but decays if exposed to wet, and is much eaten by white ants; but being plentiful and cheap it is often used for common work. It has been found excellent for staves and headings for hogsheads and barrels. It is also fairly good for charcoal-making. The weight of the wood is 42 lb. per cubic foot.

59. MANGROVE, BLACK (*Avicennia nitida*, Jacq.).

This is a small tree growing in swamps along the coast. It is called 'native oak' which it resembles, but is darker and harder. It is excellent for piles, poles, posts, etc.

60. MANGROVE, RED (*Rhizophora Mangle*, Linn.).

A tree 20 to 40 feet high forming thickets along swampy shores. The diameter of the stems is up to 15 or 20 inches and they are generally used for piles, poles, fence posts, and for building purposes. The bark is used for tanning, especially sole leather.

61. MANGROVE, WHITE (*Laguncularia racemosa*, Gaertn. f.).

A smaller tree than the red mangrove, with which, and the black mangrove, it forms the mangrove swamps in salt marshes. The wood is frequently employed for building, and it furnishes 'knees' for boats.

62. MOSQUITO WOOD (*Mosquitoxylum jamaicense*, Kr. & Urb.).

This tree was unknown to science until described by Professors Krug and Urban in 1899, from specimens collected by Mr. deB. Spencer Heaven, and forwarded from the Herbarium of the Department of Public Gardens. The tree is found in woods in the parishes of St. Elizabeth, St. James, Hanover, and Westmoreland. Mr. Heaven states: 'Mosquito wood is very good for building purposes but not so good for posts in the ground; I have it quite good in buildings about 20 years old.' Mr. Dutton Trench, of Hazelymph, St. James, states: 'Mosquito wood is most valuable for any work. It is generally found to be hollow, the heart of the wood being inferior to the outer wood; it is rarely sawn into boards.' The tree grows to a height of 50 feet with a trunk diameter of 1½ to 3 feet.

63. MOUNTAIN GUAVA (*Psidium montanum*, Sw.).

This is a tall tree, often attaining a height of 100 feet and over 2 feet in diameter, found at altitudes from 2,000 to 6,000 feet. The wood is very hard and useful only for gun-stocks and such articles as require hard, tough wood. It weighs about 65 lb. per cubic foot.

64. NASEBERRY (*Achras Sapota*, Linn.).

This is a tall fruit tree, growing to a height of 100 feet with trunk diameter up to 3 feet. The wood is heavy, hard, durable, and red in colour. It is adapted for inside house work, cabinet-making and furniture, but is difficult to work on account of its extreme hardness. Its weight is 74 lb. per cubic foot.

65. NASEBERRY BULLET, OR BULLY TREE (*Mimusops Sideroxylon*, Pierre.).

A tall, straight tree, attaining a height of over 100 feet with trunk diameter up to 6 feet. It is generally distributed, especially in the central and western parishes. The wood is very heavy but is good for general purposes. It weighs over 74 lb. per cubic foot.

66. NICKEL, OR BEAD TREE (*Ormosia jamaicensis*, Urb.).

This fine tree is known from Dominica, St. Vincent, etc., but was not known to occur in Jamaica until the writer collected specimens of it on the slopes of Dolphin Head Mountain in 1906. It there grows with a straight trunk to a height of 80 feet, with a trunk diameter up to, or over 3½ feet. The wood is useful for all kinds of house work, inside and out, rafters, posts, and for any other purpose for which lumber is employed. It is said to stand salt water well and makes good piles. Its seeds are hard, roundish, beautifully polished, and of a bright scarlet colour with a jet black spot at one end. They are used for making necklaces.

67. PARK-NUT (*Acacia macracantha*, Humb. & Bonpl.).

This is a common tree in the lowlands, attaining a height of about 25 feet, with a trunk diameter of 1½ to 2 feet. It is furnished with formidable spines. The timber is used principally for fire-wood and for charcoal-making.

68. PIGEON-WOOD (*Diospyros tetrasperma*, Sw.).

This is a small tree found chiefly on the limestone of the southern coast ranges. The timber is hard, and is good for posts and small scantlings. Wild pigeons feed on the berries.

69. PIMENTO (*Pimenta officinalis*, Lindl.).

The Allspice or Pimento tree grows to a height of 40 feet with a trunk diameter up to 2 feet, but as usually seen, it is about 15 to 20 feet high with a trunk about 9 to 12 inches in diameter. It is generally distributed, but is especially abundant in the central parishes. The wood is close-grained and exceedingly tough, and is useful for all purposes, especially in exposed situations. Only the 'male' or barren trees are cut down. Saplings are exported in large numbers to be made into walking-sticks and umbrella handles.

70. PRICKLY YELLOW (*Zanthoxylum martinicense*, D.C.).

This tree is found throughout the island, especially in the eastern districts, up to 3,500 feet altitude. It is a tall tree up to 80 feet in height with a trunk diameter up to 3 feet or over. The wood is of a light yellow colour, of fine and even grain, and is employed for furniture, cabinet work and house work, but is not considered durable for outside work. It weighs about 60 lb. per cubic foot.

71. PRUNE (*Prunus occidentalis*, Sw.).

A high tree up to 50 or 60 feet with a diameter of trunk up to 3 feet. The wood, which weighs over 66 lb. per cubic foot, is of a red colour, resembling cedar, and is very hard and durable. It is considered excellent building timber and lasts well under water. It is from the kernels of the fruit of this that the celebrated liqueur *Noyau* of Martinique is prepared. They yield a flavour much superior to that of the peach, being rich, oily, and nutty, combined with that of prussic acid. The bark has an astringent taste with a strong flavour of prussic acid and is used in manufacturing an inferior description of *Noyau* known by the name of Prune-dram.

72. RAMOOM (*Trophis americana*, Linn.).

Found with, and on both sides of the zone occupied by the breadnut. It grows to a height of about 30 feet and is chiefly useful for the nutritious fodder it yields for cattle and horses. Its wood is good for all purposes except in exposed situations.

73. RED, OR CHERRY BULLY TREE, OR GALIMENTA (*Dipholis nigra*, Griseb.).

General all over the island below 3,500 feet altitude. A large tree affording a hard, heavy and close-grained timber, weighing over 71 lb. per cubic foot, and used largely in general construction, also for shingles.

74. RED-BEAD TREE (*Adenanthera pavonina*, Linn.).

An introduced tree, but now naturalized in many parts of the island. The red heart-wood is used in India as a substitute for red sandal wood. It is hard, close-grained, strong and durable, and is used for house building and cabinet making. The scarlet seeds, known as Circassian seeds, are used for making necklaces, etc.

75. ROSEWOOD (*Drypetes ilicifolia*, Kr. & Urb.).

This tree was only known from Porto Rico until the writer discovered it in Westmoreland, Jamaica, in 1898. It is a forest tree attaining a height of 50 feet and a trunk diameter of 2 to 3 feet. It is said to be a valuable timber for general purposes, but further information is required as to its uses. This may be Harrison's *Amyris* sp.

76. ROSEWOOD OR TORCH-WOOD (*Amyris balsamifera*, Linn.).

A small tree 15 to 20 feet high. The wood is hard and is useful for all purposes for which it is suited, especially in exposed situations. It is also used in cabinet making. It splits readily into strips and is used by the peasantry for torches.

77. SANTA MARIA (*Calophyllum Calaba*, Jacq.).

A lofty tree, as straight as a ship's mast and reaching a height of 150 feet, and 5 feet or over in diameter. The tree is very abundant in humid localities at from 1,500 to 3,000 feet altitude. The wood is of a white to reddish colour, hard, and

durable. It is used for constructional work, ship-building, and heavy machine work; for posts, furniture, felloes of wheels, and largely for shingles. Its weight is 46 lb. per cubic foot.

78. SAPODILLA (*Mimusops excisa*, Urb.).

This is a new species not known botanically until specimens were collected by the writer in 1904. It is a large timber tree, 40 to 80 feet high and with a trunk diameter up to 4 feet. It grows in the Cockpit Country and in the Clarendon Mountains, from 1,500 to 3,000 feet altitude. It has large leaves which are light-green above and reddish-gold colour beneath, and it forms a prominent feature on the rocky hills. The tree abounds in a viscid milky juice. The wood when seasoned is almost black, and is hard, heavy and durable. It has been used for railway sleepers, but it becomes so hard that it is almost impossible to drive a spike into it, and on that account, I understand, its use was discontinued. It is used for general purposes, especially in exposed situations.

79. SATIN-WOOD (*Fagara flava*, Kr. & Urb.).

This is a comparatively small tree, from 12 to 35 feet high with a trunk 8 to 18 inches in diameter, and is found on the southern hills of St. Catherine, Clarendon, Manchester, St. Elizabeth, etc. It has no distinct heart-wood, but the colour gradually deepens from a light yellow at the bark inwards to a light orange at the centre. It is even-grained, of a satiny lustre in longitudinal section, and showing on its polished surface a beautifully rippled pattern. It is aromatic like the true satin-wood of the East Indies, when first out. Its weight is about 60 lb. per cubic foot, and its crushing strength 4·31 tons per square inch. It is a great favourite for veneering, panels, cabinet work, and furniture. Its value is from £6 to £7 per ton in London.

80. SEA-SIDE GRAPE (*Coccoloba uvifera*, Linn.).

A crooked tree found along the coast. In Jamaica it is usually a small tree, though occasionally specimens reaching a height of 40 or 50 feet may be seen. The wood is hard, takes a fine polish, and may be used for fancy work. Its weight is 65 lb. per cubic foot, and its crushing strength 2·51 tons per square inch.

81. SHAD-BARK AND TAMARIND SHAD-BARK.

There are three trees nearly related, but botanically distinct, which are known as shad-bark, or tamarind shad-bark. All three were collected by the writer and are as follows:—

1. Tamarind Shad-bark (*Pithecolobium Alexandri*, Urb.). A tree up to 50 feet high, collected at Holly Mount, Mount Diablo in 1905. Leaflets 8 to 16 jugal, ¾ inch long, ⅜ inch broad.

2. Tamarind Shad-bark (*Pithecolobium Alexandri*, Urb., var. *intermedium*, Urb.). A tree 40 feet high, collected near Catadupa in the Cockpit Country in 1906. Leaflets 5 to 8 jugal, 1 inch long, ½ inch broad.

3. Shad-bark (*Pithecolobium Alexandri*, Urb., var. *Troyanum*, Urb.). A tree 30 to 40 feet high, collected near Troy in the Cockpit Country in 1904. Leaflets 3 to 4 jugal, 1½ inches long, ⅝ inch broad.

The pods in each case form a complete spiral, and are about 3½ inches long, and ½ inch wide. The pretty seeds, which are highly polished, slightly flattened, and in colour one-half milky white, and one-half pale to dark blue, are used for necklaces.

All three trees yield valuable timber useful for general purposes. The variety *Troyanum* has been supplied to the Government railway for sleepers, and it gives useful boards, planks and scantlings.

82. SILK-COTTON, OR CEIBA (*Eriodendron anfractuosum*, DC.).

A very large spreading tree, growing in the open, with twisted, far-extending buttresses. It attains a height of 60 to 80 feet or more, with a trunk diameter up to 10 or 12 feet. The wood is soft and subject to the attacks of insects, and is only used for making dug-out canoes which do not last long. It is said, however, that if steeped in strong lime water the wood will last for several years, even when made into boards, shingles, etc.

83. SLUG-WOOD (*Beilschmiedia pendula*, Hemsl.).

A tree 25 to 30 feet high, with a trunk diameter up to 2 feet, found in mountain woods in wet districts. It produces a good hardwood, suitable for any purpose, and especially for exposed positions.

84. SOAP-BERRY (*Sapindus Saponaria*, Linn.).

A tree 15 to 30 feet high, fairly common on the south side of the island and on the hills above Liguanea. The wood is soft and not very valuable, but it is used in cabinet work.

85. SOAP-WOOD (*Clethra tinifolia*, Sw.).

This tree is generally distributed in damp districts from 1,500 feet altitude upwards. In the Blue Mountain districts it is a small tree, but in the interior forests of Trelawny, etc., it grows to a height of 60 to 80 feet. The wood is useful for all purposes except in exposed situations. It makes fairly good shingles.

86. SPANISH ELM (*Cordia gerascanthoides*, H.B. & K.).

A tree 20 to 50 feet high, with a trunk diameter up to 2 or 2½ feet. Generally distributed throughout the island at 1,000 to 2,000 feet altitude. The wood is used in carriage building, coopering, and for general purposes, except in exposed situations. Also for cabinet work. It makes a good post to go in the ground. It weighs nearly 48 lb. per cubic foot.

87. STAR APPLE (*Chrysophyllum Cainito*, Linn.).

A handsome fruit tree of moderate dimensions, the underside of the leaves being of a beautiful golden hue. The wood is very hard and durable, and suitable for all purposes, especially for exposed situations.

88. SUMACH, HOG DOCTOR, POISON WOOD, BOAR WOOD (*Rhus Metopium*, Linn.).

A tree 15 to 40 feet in height, common on the southern limestone hills. It affords a good timber of light colour and texture. The juice of the tree is reputed to be very poisonous.

89. SWEET-WOOD, LOBLOLLY (*Ocotea Leucoxylon*, Mez.).

A medium-sized tree, generally distributed in mountain woods. Its timber is useful for all purposes except in exposed situations; it is also suitable for staves and headings of hogsheads and barrels.

90. SWEET-WOOD, TIMBER (*Nectandra exaltata*, Griseb.).

A common tree up to 3,000 feet altitude. It attains a height of 50 feet with a diameter up to 2½ feet. The wood is brownish in colour, with a tinge of green. It weighs 53 lb. per cubic foot. It is a dense, solid wood resembling greenheart, but is liable to crack in the sun. It is used for general interior work, and is suitable for shingles.

91. SWEET-WOOD, YELLOW (*Nectandra Antillana*, Meissn.).

This is a common tree up to 3,000 feet altitude. It attains a height of about 40 feet, with a trunk diameter up to 3 feet. The wood saws and splits freely, and it is very good timber for general purposes except in exposed situations. Shingles are made from it and it is suitable for staves and headings of hogsheads and barrels.

92. TAMARIND (*Tamarindus indica*, Linn.).

An introduced, but naturalized tree, found everywhere up to about 3,000 feet altitude. In the open plains it is often a very large tree with a trunk diameter up to 5 feet. The wood is heavy, tough, and elastic, of a yellowish-white colour, with irregular blotches of purplish brown heart-wood. It is very hard and difficult to work, and is applicable for turnery, handles of axes, and other tools. The heart-wood gives a handsome furniture timber, and it is used in cabinet work. The pulp of the pods, which is laxative and refrigerant, is preserved in boiling syrup.

93. *Tetrorchidium rubrivenium*, Poepp. & Endl., var. *integrifolium*, Muell. Arg.

This is a new tree for Jamaica, first collected by the writer at Holly Mount, Mount Diablo, in 1903. It is of medium size, about 25 to 30 feet high, and is said to give a useful timber for general purposes, but definite information on this point is needed.

94. TORCH-WOOD, OR FLAMBEAU (*Tecoma stans*, Juss.).

This is a small tree, very abundant on the southern limestone hills, and on the plains. The wood is extremely durable, hard, and heavy, with the annual rings distinctly marked in cross-sections. It is excellent for posts and outside work, such as fences.

95. WEST INDIAN BIRCH, OR MASTIC (*Bursera gummifera*, Linn.).

This is a tree of the coast and coast ranges, and is very abundant. It is usually about 25 to 30 feet high with a trunk diameter of 2 feet, but is often very much larger. It is a very striking tree along the coast, with its swollen trunk and reddish bark, which scales off. The timber is white and soft and is only used in coopering, and as firewood.

96. WHITE-WOOD (*Tecoma leucoxylon*, Mart.).

A small tree with pale rosy, or white flowers, common on the southern costal limestone hills. The wood is very hard and durable, and makes excellent posts and piles, and is suitable for general purposes in exposed positions.

97. WILD CASSADA (*Turpinia occidentalis*, G. Don.)

This is a common tree from about 1,000 feet to 6,000 feet altitude. It attains a height of 40 feet with a trunk diameter of 2 feet. The timber is good for general purposes, except in exposed situations; also for staves and headings of barrels.

98. WILD JUNIPER (*Lyonia jamaicensis*, D. Don., and *L. octandra*, Griseb.).

These small trees are confined to the mountains: the first-named ranges from 1,500 feet to 5,000 feet altitude, and the second is usually found above 5,000 feet. The wood is very hard and durable, and is considered excellent for posts, and other work in exposed situations.

99. WILD ORANGE (*Esenbeckia pentaphylla*, Griseb.).

A tree up to 50 feet in height; generally distributed, but most plentiful in the western parishes. It affords an excellent timber for general purposes in interior work; also used for cabinet work.

100. WILD TAMARIND (*Pithecolobium arboreum*, Urb.).

A handsome tree, generally distributed up to 3,000 feet altitude. It is usually a tree of 40 feet high with a trunk diameter of 2 to 3 feet, but it often attains a height of 60 feet, and up to 4 feet in diameter. It affords an excellent timber, much used in building, and is in general use for flooring, ceilings, and ornamental work.

101. WOMAN'S TONGUE, OR EAST INDIAN WALNUT (*Albizzia Lebbek*, Benth.).

An introduced tree, but now very common on the lowlands, The wood which is dark-brown, walnut colour, seasons, works, and polishes well, and is fairly durable. It is used for furniture boats, sugar-cane crushers, oil mills, picture frames, etc. It weighs 41 to 56 ℔. per cubic foot.

102. YACCA, BLUE MOUNTAIN (*Podocarpus Urbanii*, Pilger.).

This fine tree is confined to the Blue Mountains, from 3,000 feet up to the summit of the Blue Mountain Peak (7,423 feet). It is a large tree, attaining a height of 50 to 60 feet, with a trunk diameter up to 5 feet. Usually, however, it is a tree 30 feet high with a trunk 2 to 3 feet in diameter. The wood weighs 47 ℔. per cubic foot, and has a crushing strength of 2 55 tons per square inch. The wood is often cross-grained, and beautifully marked, and is highly prized and much used for furniture, the interior of buildings, and cabinet work.

103. YACCA, ST. ANN'S (*Podocarpus Purdieana*, Hook.).

This is a very large tree found in the forests of the central and western parishes. It attains a height of 80 to 150 feet, with a trunk diameter of 2 to 6 feet. It produces excellent timber, heavy, hard and durable, suitable for all purposes. It is not, however, so ornamental as the Blue Mountain Yacca.

104. YELLOW CANDLE-WOOD (*Cassia emarginata*, Linn.).

A small tree not exceeding 20 feet in height, common on the savannahs and hills near the coast. It is a dye-wood, and has been exported to some extent. It is too small to be sawn for timber, but as it is a hardwood it is useful for cabinet work, for posts. It is largely used for firewood.

105. YELLOW SANDERS, WILD OLIVE, NEGRESSE (*Buchenavia capitata*, Eichl.).

A large tree 30 to 60 feet high, and up to 4 feet in diameter, found chiefly in the interior of the central districts. The wood, which weighs over 57 ℔. per cubic foot, is of a light yellow colour, with satin graining, and is highly prized for cabinet work, and it is suitable for general purposes, especially in exposed situations. It is also used for shingles.

106. YOKE-WOOD MAST-WOOD, FRENCH OAK, SPANISH OAK (*Catalpa longissima*, Sims.).

This tree is very abundant along the south and south-east coast, not often seen above 1,500 feet altitude. The tree grows to a height of 60 feet with a diameter of trunk up to 4 feet. The wood is light brownish-grey, with cross-stripes of a darker colour, and somewhat resembles walnut. It weighs 70 ℔. pr cubic foot, and has a crushing strength of 2·09 tons per square inch. It is one of the most useful and best of timbers for boards and scantlings, very durable, and not too hard for general purposes.

107. ZEBRA-WOOD, SATIN-WOOD (*Zanthoxylum caribaeum*. Lam.)

A large tree, up to 50 feet in height with a diameter up to 4 feet. Found throughout the island, but especially common in the eastern districts up to 3,000 feet altitude. The wood is of a light yellow colour, beautifully waved and mottled. It takes a high polish, and is highly prized for cabinet work, and for interior ornamental work.

108. ZEBRA-WOOD, MOUNTAIN (*Eugenia fragrans*, Willd.).

Usually a small tree, but on the slopes of the Blue Mountains it grows to a height of 50 feet with a trunk diameter up to 3 feet. It is very hard and durable wood, suitable for any purpose, and especially in exposed situations.

VALUE OF NATIVE LUMBER.

The value of native lumber, such as mahogany, cedar, mahoe, bully tree, etc., on the spot in the interior is about 14*s*. per 100 superficial feet for boards. Trees are valued at the rate of 1*s*. per 100 feet of the boards which theyare estimated to yield. To a wholesale buyer the price would be lower.

The cost of felling timber and hand-sawing lumber is usually as follows: Boards £4 to £5 per 1,000 superficial feet

Scantlings £3 per 1,000.

And of splitting shingles 18*s*. to 20*s*. per 1,000.

To the above prices must be added the cost of removing the lumber from the sawpit to the nearest cart-road; and of drayage to the nearest railway station or port.

The value of such lumber delivered at Kingston is now about £10 per 1,000 superficial feet, and of shingles, such as cedar and mahoe, about 62*s*. per 1,000.

The prices of imported lumber are now as follows:—

White Pine, rough,	£9	per 1,000	superficial	feet.
„ „ dressed,	£9 10*s*.	„	„	„
Pitch Pine, rough,	£9 10*s*.	„	„	„
„ „ dressed	£10	„	„	„

Dressed Cyprus shingles, 72*s*.

The prices for imported lumber have increased about 30 per cent. within the last few years, and the general opinion is that, whilst the prices have increased, the quality has deteriorated. It does not come within the scope of this paper to enter into a discussion on the important questions of forest conservation, or of forests in their relation to rainfall and the conservation of moisture.

USES OF NATIVE LUMBER.

LIST OF WOODS SUITABLE FOR CABINET WORK.

Local Name.	*Botanical Name.*
Braziletto	*Peltophorum Linnaei*, Benth.
Breadfruit	*Artocarpus incisa*, Linn.
Breadnut	*Brosimum Alicastrum*, Sw.
Cashew...	*Anacardium occidentale*, Linn.
Cedar, Juniper	*Juniperus bermudiana*, Linn.
Cedar, West Indian	*Cedrela odorata*, Linn.
Cocoa-nut	*Cocos nucifera*, Linn.
Dog-wood	*Piscidia Erythrina*, Linn.
Ebony, or Cocus Wood ...	*Brya Ebenus*, DC.
Fiddle-wood	*Petitia domingensis*, Jacq.
Fustic	*Chlorophora tinctoria*, Gaud.
Greenheart, or Break-axe ...	*Sloanea jamaicensis*, Hook.
Gru-gru Palm	*Acrocomia lasiospatha*, Mart.
Horse-wood	*Pithecolobium latifolium*, Benth.
Indian Tulip Tree	*Thespesia populnea*, Soland.
Jack Fruit	*Artocarpus integrifolia*, Linn.
Lignum-vitae	*Guaiacum officinale*, Linn.
Locust Tree	*Hymenaea Courbaril*, Linn.
Logwood	*Haematoxylon campechianum*, Linn.
Mahoe, Blue or Mountain ...	*Hibiscus elatus*, Sw.
Mahogany	*Swietenia Mahagoni*, Jacq.
Mangrove	*Avicennia nitida*, Jacq.
Musquito-wood	*Mosquitoxylum jamaicense*, Kr. & Urb.
Naseberry	*Achras Sapota*, Linn.
Naseberry Bullet or Bully Tree	*Mimusops Sideroxylon*, Pierre.
Pigeon-wood	*Diospyros tetrasperma*, Sw.
Prickly Yellow	*Zanthoxylum martinicense*, DC.
Red-Bead Tree	*Adenanthera pavonina*, Linn.
Rosewood or Torch-wood ...	*Amyris balsamifera*, Linn.
Sapodilla	*Mimusops excisa*, Urb.
Satin-wood	*Fagara flava*, Kr. & Urb.
Sea-side Grape	*Coccoloba uvifera*, Linn.
Soap-berry	*Sapindus Saponaria*, Linn.
Spanish Elm	*Cordia gerascanthoides*, H.B. & K.
Star apple	*Chrysophyllum Cainito*, Linn.
Sumach, Hog Doctor, etc. ...	*Rhus Metopium*, Linn.
Tamarind	*Tamarindus indica*, Linn.
Wild Orange	*Esenbeckia pentaphylla*, Griseb.
Wild Tamarind	*Pithecolobium arboreum*, Urb.
Woman's Tongue	*Albizzia Lebbek*, Benth.
Yacca, Blue Mountain ...	*Podocarpus Urbanii*, Pilger.
Yacca, St. Ann's	*Podocarpus Purdieana*, Hook.
Yellow Candlewood	*Cassia emarginata*, Linn.
Yellow Sanders, etc.	*Buchenavia capitata*, Eichl.
Yoke-wood, Mastwood, etc.	*Catalpa longissima*, Sims.
Zebra-wood, Satin-wood ...	*Zanthoxylum caribaeum*, Lam.
Zebra-wood, Mountain ...	*Eugenia fragrans*, Willd.

LIST OF WOODS SUITABLE FOR CARRIAGE AND CART WORK.

Local Name.	*Botanical Name.*	*Remarks*
Bastard Cabbage Bark or Angelin	*Andira inermis*, H. B. & K.	
Braziletto	*Peltophorum Linnaei*, Benth.	Spokes.
Calabash	*Crescentia Cujete*, Linn.	
Cashaw	*Prosopis juliflora*, DC.	
Cedar, West Indian	*Cedrela odorata*, Linn.	
Dog-wood	*Piscidia Erythrina*, Linn.	For naves and felloes.
Fiddle-wood ...	*Petitia domingensis*, Jacq.	For felloes.
Fustic	*Chlorophora tinctoria*, Gaud.	Naves and wheels.
Indian Tulip Tree	*Thespesia populnea*, Soland.	
Lancewood, Black	*Bocagea virgata*, B. & H.	For shafts and poles.
Lancewood, White	*Bocagea laurifolia*, B. & H.	For shafts and poles.
Mahoe	*Hibiscus elatus*, Sw.	For felloes.
Naseberry Bully, or Bullet Tree ...	*Mimusops Sideroxylon*, Pierre.	For spokes.
Pimento	*Pimenta officinalis*, Lindl.	For tongues and shafts.
Santa Maria ..	*Calophyllum Calaba*, Jacq.	For felloes.
Sapodilla	*Mimusops excisa*, Urb.	For spokes.
Spanish Elm ...	*Cordia gerascanthoides*, H.B. & K.	For tongues and shafts.

LIST OF WOODS SUITABLE FOR COOPERING WORK.

Broad-leaf	*Terminalia latifolia*, Sw.
Clammy Cherry	*Cordia Collococca*, Linn.
Hog Plum	*Spondias lutea*, Linn.
Mango	*Mangifera indica*, Linn.
Sweet-wood, Loblolly ...	*Ocotea Leucoxylon*, Mez.
Sweet-wood, Yellow... ..	*Nectandra antillana*, Meissn.
West Indian Birch, or Mastic	*Bursera gummifera*, Linn.
Wild Cassada	*Turpinia occidentalis*, G. Don.

LIST OF WOODS SUITABLE FOR FUEL.

———	*Acacia tortuosa*, Willd.
Cashaw	*Prosopis juliflora*, DC.
Mango	*Mangifera indica*, Linn.
Park-nut	*Acacia macracantha*, Humb. & Bonpl.
West Indian Birch, or Mastic	*Bursera gummifera*, Linn.
Yellow Candle-wood... ...	*Cassia emarginata*, Linn.

LIST OF WOODS SUITABLE FOR GENERAL PURPOSES.

(Inside work.)

Local Name.	*Botanical Name.*
Akee	*Blighia sapida*, Koen.
Bastard Cedar	*Guazuma tomentosa*, H.B. & K.
Bitter Dan, Bitter Damson, Stavewood	*Simaruba glauca*, DC.
Bread-nut	*Brosimum Alicastrum*, Sw.
Broad-leaf	*Terminalia latifolia*, Sw.
Cedar, West Indian	*Cedrela odorata*, Linn.
Clammy Cherry ...	*Cordia Collococca*, Linn.
Ginep	*Melicocca bijuga*, Linn.
Guango...	*Pithecolobium Saman*, Benth.
Lignum Dorum	*Ocotea staminea*, Mez.
Locust-berry, or Hog-berry	*Byrsonima crassifolia*, H.B. & K. var. *jamaicensis*, Urb. & Neid.
Mahoe, Sea-side	*Hibiscus tiliaceus*, Linn.
Mahogany	*Swietenia Mahagoni*, Jacq.
Mammee Sapota	*Calocarpum mammosum*, Pierre.
Mango	*Mangifera indica*, Linn.
Prune	*Prunus occidentalis*, Sw.
Ramoon	*Trophis americana*, Linn.
Red, or Cherry Bull Tree, or Galimenta	*Dipholis nigra*, Griseb.
Santa Maria	*Calophyllum Calaba*, Jacq.
Shad-bark	*Pithecolobium Alexandri*, Urb., and varieties.
Silk-cotton, or Ceiba ...	*Eriodendron anfractuosum*, DC.
Soap-wood	*Clethra tinifolia*, Sw.
Spanish Elm	*Cordia gerascanthoides*, H.B. & K.
Sumach, Hog Doctor, etc. ...	*Rhus Metopium*, Linn.
Sweet-wood, Loblolly ...	*Ocotea Leucoxylon*, Mez.
Sweet-wood, Yellow	*Nectandra antillana*, Meissn.
Wild Cassada	*Turpinia occidentalis*, G. Don.
Wild Tamarind	*Pithecolobium arboreum*, Urb.
Yacca, Blue Mountain ...	*Podocarpus Urbanii*, Pilger.
Yacca, St. Ann's	*Podocarpus Purdieanna*, Hook.
Yoke-wood, Mast-wood ...	*Catalpa longissima*, Sims.

LIST OF WOODS SUITABLE FOR GENERAL PURPOSES.

(Exposed situations.)

Bastard Cabbage Bark, or Angelin	*Andira inermis*, H.B. & K.
Blind-eye, or Yucco	*Sapium cuneatum*, Griseb.
Blood-wood, or Iron-wood ...	*Laplacea Haematoxylon*, G. Don.
Boxwood, or Fiddle-wood ...	*Vitex umbrosa*, Sw.
Braziletto	*Peltophorum Linnaei*, Benth.
Bullet, or Bully Tree, Mountain	*Dipholis montana*, Griseb.
Cashaw...	*Prosopis juliflora*, DC.
Cashew	*Anacardium occidentale*, Linn.

LIST OF WOODS SUITABLE FOR GENERAL PURPOSES.—(*Concluded.*)

(Exposed situations.)

Local Name.	*Botanical Name.*
Cedar, Juniper	*Juniperus bermudiana*, Linn.
Cedar, West Indian	*Cedrela odorata*, Linn.
Cro-cro	*Tecoma Brittonii*, Urb.
Cromanty	*Matayba apetala*, Radlk.
Fiddle-wood	*Petitia domingensis*, Jacq.
Greenheart, or Break-axe ...	*Sloanea jamaicensis*, Hook.
Gutter-wood	*Strempeliopsis arborea*, Urb.
Horse-wood	*Pithecolobium latifolium*, Benth.
———	*Ilex obcordata*, Sw.
Mammee Apple	*Mammea americana*, Linn.
Mammee Sapota	*Calocarpum mammosum*, Pierre.
Mangrove, Red	*Rhizophora Mangle*, Linn.
Mosquito-wood	*Mosquitoxylum jamaicense*, Kr. & Urb.
Naseberry Bullet, or Bully Tree	*Mimusops Sideroxylon*, Pierre.
Nickel, or Bead Tree	*Ormosia jamaicensis*, Urb.
Pimento	*Pimenta officinalis*, Lindl.
Prune	*Prunus occidentalis*, Sw.
Red-bead Tree	*Adenanthera pavonina*, Linn.
Red, or Cherry Bully Tree, or Galimenta	*Dipholis nigra*, Griseb.
Rosewood	*Drypetes ilicifolia*, Kr. & Urb.
Rosewood, or Torch-wood ...	*Amyris balsamifera*, Linn.
Santa Maria	*Calophyllum Calaba*, Jacq.
Sapodilla	*Mimusops excisa*, Urb.
Shad-bark	*Pithecolobium Alexandri*, Urb. and varieties.
Slug-wood	*Beilschmiedia pendula*, Hemsl.
Star Apple	*Chrysophyllum Cainito*, Linn.
———	*Tetrochidium rubrivenium*, Poepp. & Endl, var. *integrifolium*, Muell. Arg.
Wild Juniper	*Lyonia jamaicensis*, D. Don and *L. octandra*, Griseb.
Yacca, St. Ann's	*Podocarpus Purdieana*, Hook.
Yellow Sanders, etc.... ...	*Buchenavia capitata*, Eichl.
Yoke-wood, Mast-wood, etc.	*Catalpa longissima*, Sims.
Zebra-wood, Mountain ...	*Eugenia fragrans*, Willd.

LIST OF WOODS SUITABLE FOR HOUSEWORK AND FURNITURE.

Almond, Tropical	*Terminalia Catappa*, Linn.
Breadfruit	*Artocarpus incisa*, Linn.
Bread-nut, ...	*Brosimum Alicastrum*, Sw.
Cedar, Juniper	*Juniperus bermudiana*, Linn.
Cedar, West Indian	*Credrela odorata*, Linn.
Cocoa-nut	*Cocos nucifera*, Linn.
Fiddle-wood	*Petitia domingensis*, Jacq.
Fustic	*Chlorophora tinctoria*, Gaud.
Hog Gum	*Symphonia globulifera*, Linn. f.
Indian Tulip Tree	*Thespesia populnea*, Soland.

LIST OF WOODS SUITABLE FOR HOUSEWORK AND FURNITURE.
(*Concluded.*)

Local Name.	*Botanical Name.*
Jack Fruit	*Artocarpus integrifolia*, Linn.
Locust Tree	*Hymenaea Courbaril*, Linn.
Mahoe, Blue or Mountain ...	*Hibiscus elatus*, Sw.
Mahogany	*Swietenia Mahagoni*, Jacq.
Mammee Sapota	*Calocarpum mammosum*, Pierre.
Mangrove, White	*Laguncularia racemosa*, Gaertn.f.
Mosquito-wood	*Mosquitoxylum jamaicense*, Kr. & Urb.
Naseberry	*Achras Sapota*, Linn.
Naseberry Bullet, or Bully Tree	*Mimusops Sideroxylon*, Pierre.
Nickel, or Bead Tree	*Ormosia jamaicensis*, Urb.
Prickly Yellow	*Zanthoxylum martinicense*, DC.
Red-bead Tree	*Adenanthera pavonina*, Linn.
Red, or Cherry Bully Tree, or Galimenta	*Dipholis nigra*, Griseb.
Santa Maria	*Calophyllum Calaba*, Jacq.
Satin-wood	*Fagara flava*, Kr. & Urb.
Sumach, Hog Doctor, etc. ...	*Rhus Metopium*, Linn.
Sweet-wood, Timber... ...	*Nectandra exaltata*, Griseb.
Tamarind	*Tamarindus indica*, Linn.
Wild Orange	*Esenbeckia pentaphylla*, Griseb.
Wild Tamarind	*Pithecolobium arboreum*, Urb.
Woman's Tongue	*Albizzia Lebbek*, Benth.
Yacca, Blue Mountain ...	*Podocarpus Urbanii*, Pilger.
Yacca, St. Ann's	*Podocarpus Pardieana*, Hook.
Yoke-wood, Mast-wood, etc.	*Catalpa longissima*, Sims.
Zebra wood, Satin-wood ...	*Zanthoxylum caribaeum*, Lam.

LIST OF WOODS SUITABLE FOR MILL WORK.

Blood-wood	*Laplacea Haematoxylon*, G. Don.
Cogwood, or Greenheart ...	*Zizyphus chloroxylon*, Oliv.
Dog-wood	*Piscidia Erythrina*, Linn.
Green-heart, or Break-axe ...	*Sloanea jamaicensis*, Hook.
Lignum-vitae	*Guaiacum officinale*. Linn.
Locust Tree	*Hymenaea Courbaril*, Linn.
Santa Maria	*Calophyllum Calaba*, Jacq.
Woman's Tongue	*Albizzia Lebbek*, Benth.

LIST OF WOODS SUITABLE FOR PILES.

Bastard Cabbage Bark, or Angelin	*Andira inermis*, H. B. & K.
Blind-eye or Yucco	*Sapium cuneatum*, Griseb.
Button-wood	*Conocarpus erectus*, Linn.
Cocoa-nut	*Cocos nucifera*, Linn.
Dogwood	*Piscidia Erythrina*, Linn.
Fiddle-wood	*Petitia domingensis*, Jacq.

LIST OF WOODS SUITABLE FOR PILES.—(*Concluded.*)

Local Name.	*Botanical Name.*
Mammee Apple	*Mammea americana*, Linn.
Mangrove, Black	*Avicennia nitida*, Jacq.
Mangrove, Red	*Rhizophora Mangle*, Linn.
Nickel, or Bead Tree... ...	*Ormosia jamaicensis*, Urb.
Prune	*Prunus occidentalis*, Sw.
White-wood	*Tecoma leucoxylon*, Mart.

LIST OF WOODS SUITABLE FOR POSTS.

Blood-wood, or Iron-wood ...	*Laplacea Haematoxylon*, G. Don.
Button-wood	*Conocarpus erectus*, Linn.
Cashaw...	*Prosopis juliflora*, DC.
Cedar, Juniper	*Juniperus bermudiana*, Linn.
Horse-wood	*Pithecolobium latifolium*, Benth.
Logwood	*Haematoxylon campechianum*, Linn.
Maiden Plum	*Comocladia integrifolia*, Jacq.
Maiden Plum	*Comocladia velutina*, Britton.
Mammee Apple	*Mammea americana*, Linn.
Mangrove, Black	*Avicennia nitida*, Jacq.
Mangrove, Red	*Rhizophora Mangle*, Linn.
Pigeon-wood	*Diospyros tetrasperma*, Sw.
Spanish Elm	*Cordia gerascanthoides*, H.B.& K.
Torch-wood or Flambeau ...	*Tecoma stans*, Juss.
White-wood	*Tecoma leucoxylon*, Mart.
Wild Juniper	*Lyonia jamaicensis*, D. Don, and *L. octandra*, Griseb.
Yellow Candle-wood... ...	*Cassia emarginata*, Linn.

LIST OF WOODS SUITABLE FOR RAILWAY SLEEPERS.

Blind-eye, or Yucco	*Sapium cuneatum*, Griseb.
Braziletto	*Peltophorum Linnaei*, Benth.
Cashaw...	*Prosopis juliflora*, DC.
Dog-wood	*Piscidia Erythrina*, Linn.
Fiddle-wood	*Petitia domingensis*, Jacq.
Mahoe, Blue or Mountain ..	*Hibiscus elatus*, Sw.
Sapodilla	*Mimusops excisa*, Urb.
Shad-bark	*Pithecolobium Alexandri*, var. *Troyanum*, Urb.

LIST OF WOODS SUITABLE FOR SHINGLES.

Alligator-wood	*Guarea trichilioides*, Linn.
Broad-leaf	*Terminalia latifolia*, Sw.
Bullet, or Bully Tree, Mountain	*Diphodis montana*, Griseb.
Cedar, West Indian	*Cedrela odorata*, Linn.
Hog Gum	*Symphonia globulifera*, Linn.f.

LIST OF WOODS SUITABLE FOR SHINGLES.—(*Concluded.*)

Local Name.	*Botanical Name.*
Lignum Dorum	*Ocotea staminea*, Mez.
Mahoe, Blue or Mountain, ...	*Hibiscus elatus*, Sw.
Red, or Cherry Bully tree, or Galimenta	*Dipholis nigra*, Griseb.
Santa Maria	*Calophyllum Calaba*, Jacq.
Silk-cotton, or Ceiba	*Eriodendron anfractuosum*, DC.
Soap-wood	*Clethra tinifolia*, Sw.
Sweet-wood, Yellow	*Nectandra Antillana*, Meissn.
Sweet-wood, Timber	*Nectandra exaltata*, Griseb.
Yellow Sanders, etc.	*Buchenaria capitata*, Eichl.

LIST OF WOODS SUITABLE FOR TURNERY.

Blood-wood, or Iron-wood ...	*Laplacea Haematoxylon*, G. Don.
Calabash	*Crescentia Cujete*, Linn.
Cocoa-nut palm	*Cocos nucifera*, Linn.
Dog-wood	*Piscidia Erythrina*, Linn.
Ebony or Coccus-wood ...	*Byra Ebenus*, DC.
Greenheart or Break-axe ...	*Sloanea jamaicensis*, Hook.
Gru-Gru Palm...	*Acrocomia lasiospatha*, Mart.
Indian Tulip Tree	*Thespesia populnea*, Soland.
Jack Fruit	*Artocarpus integrifolia*, Linn.
Lancewood, Black	*Bocagea viragata*, B. & H.
Lancewood, White	*Bocagea laurifolia*, B. & H.
Lignum-vitae	*Guaiacum officinale*, Linn.
Locust Tree	*Hymenaea Courbaril*, Linn.
Maiden Plum	*Comocladia integrifolia*, Jacq.
Maiden Plum	*Comocladia velutina*, Britton.
Mountain Guava	*Psidium montanum*, Sw.
Nasberry Bullet, or Bully Tree	*Mimusops Sideroxylum*, Pierre
Sapodilla	*Mimusops excisa*, Urb.
Star Apple	*Chrysophyllum Cainito*, Linn.
Tamarind	*Tamarindus indica*, Linn.

CONCLUSION.

In 1885-6 Mr. E. D. M. Hooper, an officer of the Indian Forest Department, visited Jamaica and prepared an important report dealing with the subject in all its aspects, and it may be interesting to reproduce here a few of the paragraphs of this valuable report on the subject of forest destruction which is constantly going on.

'The system of leasing of backlands is identical all over the whole island, local differences being in the condition as to rent payment, the rendition of the land cleared or under pasture, and the notice required either way for the determination of the tenancy, but I believe proprietors are beginning to see that under the most favourable conditions the sacrifice of the woodlands is a heavy price to pay for the transient benefit of a certain class of labour, which some owners have no great difficulty in obtaining even after refusing to take tenants. It is not on private estates alone that the cultivation of forest on

yearly lease is carried on. On Crown lands it is also permitted, the interest of the Government being seen to by overseers, who are paid 25 per cent. of the rents they collect.

'Ground cultivation is very generally indulged in, the lands being under forest and far from town. Clearing these grounds, besides actually laying bare the soil to the sun and destroying the tree growth, has a harmful effect on the surrounding vegetation, exposing it on all sides to the inroads of strong winds, and on all but the honeycomb limestone, to gradual destruction by fire. This latter agent has done more towards the disappearance of forest in Jamaica than any other. It may not have affected as large an area as the cultivation, but where it has been at work, forest has been eradicated, its place being universally taken by wire grass, *Lantana*, *Dodonea*, and mango trees, these latter dotted here and there. For yam cultivation it appears essential that no shade be left overhead, so that any hardwoods, that have existed in the clearance previously, can only be reproduced by coppice growth, or by seed brought from adjoining lands. The ordinary noxious weeds notably the John Crow bush, and Pepper Elder, take immediate possession of the abandoned lands, and prevent the development of any hardwood seedlings that may come up by chance. The harm so done is the greater where already the vegetation exists under disadvantageous conditions of soil, altitude, and actual situation. Under such circumstances, the forest will naturally take longer to assume its former condition if it is not completely prevented from doing so. This is very marked in the higher levels of the Blue Mountains, where the clearings of ages gone by still remain with their limits sharply defined in the bleakest parts under a covering of fern alone.

'Descending towards the plains, the recovery of the forest is more evident, although clearances made before emancipation still remain void of all growth of the species which it formerly contained. Lastly, as we approach the sea-level, the clearances of even the present generation are less conspicuous, the vegetation is more luxuriant, and hardwoods establish themselves under favourable circumstances without passing through such a long period of delay as elsewhere.

'The cultivation of ginger has led in times past to considerable destruction of forest, and so far as I can judge, the clearing and settlement of the extreme south of the parish of Trelawny and the north of the parish of Manchester are chiefly due to this industry which has been established at the expense of the fine Santa Maria forest. This, judging from what remains, must at one time have occupied a very large area, not so very many years since. This ginger growth has in great measure been abandoned, and there is no reason to expect it to be resuscitated. But the old clearances can never be hoped to revert to forest. The increase of population at this spot will effectually prevent the old ginger grounds so reverting.

'It may therefore be stated that the chief agents of destruction at work, are the cultivators of ground provision, and in a small way, the ginger growers, who chose virgin forest soil for their work, sacrificing the forest growth of centuries to

grow two crops without any further possible advantage being reaped from the clearing of the soil, except on other than limestone soils and for establishing Guinea grass pastures. The destruction is more complete where the ground is fired, and most so when the fires spread to their highest point, and the vegetation has no longer its tropical luxuriance.

'Such then are the chief agents at work destroying the forests, and it remains to explain to what extent they are operating now and have operated in the past, and what is the sum total of their effect upon the forests of the island.

'It has been estimated that 30,000 acres of land are annually cleared for ground provisions in the island, and as this only allows an average of 2,500 acres to each parish, I think the estimate well within the mark. We have then to consider that 30,000 acres of land are cut down yearly, and this area may contain a small proportion of virgin forest with the valuable hardwood growth which nature, uninterfered with, has gradually allowed to grow up. A larger surface now being cleared will be covered with a re-growth after a previous clearing a generation or two ago, its constituent species will be less numerous in all probability and confined to those that adapt themselves to cleared areas and whose seeds are easily disseminated, while, where any press of population and difficulty of securing ground exist, the forest cleared will be a mere scrub ruinate last cleared within living memory.

'The Crown Surveyor, who estimated the clearance each year to be 30,000 acres, also estimates the total area of forest at 800,000 acres, this out of a total area of, in round numbers, 2¾ millions of acres. I am of opinion that this estimate is a sound one, both from the estimates I have made myself, parish by parish, and also taking into consideration information received from each parish. We have then 3 acres cut over annually out of every 80, or nearly 4 per cent., but of the total area fully 100,000 are never touched, being out of the range of cultivation, so that the 30,000 areas are cleared out of 700,000 areas, which is over 4 per cent. In other words, the forest land is cut over once in twenty-five years on an average, but it is more probable the lowlands are made to yield two clearings in that period, while in the interior the recovery is slower, and the soil will hardly return a crop of yams sooner than forty years from its previous cropping. No forest, however productive, could withstand clearing and burning at this rate, and this is sufficient to account for the complete denudation of the southern slopes of the Blue Mountains from 1,000 to 4,000 feet elevation. The same effect has not followed on the limestone hills, because in parts they are not adapted for cultivation, and fire applied to the soil does not spread far beyond the limit cleared. It has ensued that certain favourable spots have been constantly cultivated, while adjoining to them forest has remained untouched, except when ransacked for mahogany and other choice timbers by the nearest cultivator, and whatever the size of the forest limestone district, and however remote it may be from hibitations, you will find it permeated with provision grounds, and if there is any area available for pasture or soil for other fixed cultivation

and water handy, a settler will be found with cattle and a pimento walk, and this in the heart of limestone waste. But if the extent of the destruction has not been so great on the limestone as on the metamorphic rocks, the forest has largely suffered from provision grounds being established, for it has been constantly indented upon by the provision growers for its choice woods, until at the present day it is difficult to find valuable species represented to any extent, and the more worthless kinds have taken the upper hand and are appropriating the soil more or less exclusively.'

I know of lands on the southern slopes of the Blue Mountain range that were cleared twenty-five to thirty years for Cinchona cultivation, but a few years later this cultivation was abandoned and the lands given up to the growth of 'bush.' At the present time, that is about twenty years since the cultivation of the Cinchona trees was given up, the lands are still in 'bush.' A few soft-wooded and worthless trees have grown up, but it is impossible to get a suitable fence post off the lands referred to.

If left undisturbed for so long, it will probably be 200 years before these slopes assume any semblance in tree growth to the adjoining virgin woodlands of which they are parts, and it may be twice or thrice that length of time before they are completely re-afforested by trees of the original species.

The growth of trees of hardwooded species is extremely slow. I have known some old trees for twenty-five years, and, beyond a slight increase in growth of twiggy branches, they look no bigger to-day than they were a quarter of a century ago. Careful measurement would, no doubt, show that they have slightly increased in bulk but such increase is not discernible.

Many of our gnarled old forest giants were probably old trees when Columbus discovered the island over 400 years ago, and I have no doubt that some of them were sturdy trees a thousand years ago.

Good timber, however, such as West Indian Cedar, can be grown to a useful size in twenty-five to thirty years.

President Roosevelt, at the first Forestry Congress held at Washington over a year ago said: 'If the present rate of forest destruction is allowed to continue with nothing to offset it, timber famine in the future is inevitable.'

It is well known that the once splendid forests of the United States have been ruined through wasteful methods, and it is merely a question of time when they will be practically exhausted, as the comparatively small amount of replanting that is going on will make no very great difference in helping to supply the enormous demand which is yearly on the increase. The consequence will be that imported lumber here will become so expensive that land planted with suitable timber will be extremely valuable. I understand that hitherto the custom observed in changing the ownership of an estate has been not to take seriously into account the value of the standing timber,

excepting dye-woods and other exportable woods. The land has simply been sold at so much per acre, its location, and suitability for the cultivation of canes, bananas, or other crops, or for stock-raising being the main points considered in arriving at its value. Customs, however, are changing, and I believe that before long the amount of available useful timber will become an important item in determining the value of an estate.

For many years past large numbers of seedling timber trees have been distributed free from the Public Gardens. The difficulty that we experience in connexion with this work is to secure regular and reliable supplies of seeds. We have appointed local collectors in various parts, but they cannot always be relied upon. Sometimes they send immature seeds, which are useless, or they forget to gather them until it is too late and all have been dispersed by the wind, or eaten by the birds.

One year's notice is required by the Department to supply large orders for young timber trees.

It occasionally happens that certain kinds of trees cannot be supplied for several years, and this is due to failure to secure seeds. The Juniper Cedar, for instance, only produces crops of good seeds at intervals of several years—often five or six. Our landowners are at all times most generous in allowing officers of the Department of Public Gardens to enter their lands for the purpose of collecting seeds and specimens of tree and plants. I am personally under many obligations to owners of estates throughout the island for much kindness and assistance when on such collecting expeditions.

My thanks are due to Mr. Dutton Trench, of Hazelymph, who has specially studied the timbers of Jamaica, and who has a nice collection of small specimen blocks of the woods, for kindly supplying me with lists of timbers used for special purposes; also to Mr. R. Melloe, late Assistant Director and Chief Engineer of the Government Railway, for lists of woods used for sleepers and other works.

REFERENCES.

The following publications were consulted in preparing this paper :—

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West Indian Timbers. By John T. Rea, F.S.I., Surveyor, War Dept. *Journal Imperial Institute.* Vol. VIII, 1902. London,

The Timbers of Commerce. By Herbert Stone, F.L.S. F.R.C.I., London, 1904.

TIMBERS OF DOMINICA.

The considerable increase in the prices of lumber imported into the West Indian Islands during the past few years, and, according to the general opinion, the deterioration in its quality have recently brought forward the question as to whether the forests of some of these colonies could not provide an abundant supply of reliable and cheap lumber.

The forests of Dominica, now that many of the difficulties of transport have been removed by the improvement of the road system throughout the island, have repeatedly been suggested as being capable of providing a supply of good timber.

Some time back, an experimental steam saw-mill was introduced into the island to demonstrate the commercial value of the timbers in the forests of the interior, and plans for cutting the timbers for local use and for export to the other West Indian Islands and elsewhere are now on foot.

Information in respect to the kinds of timbers that could be obtained, and to what uses they could be put, has frequently been asked for, and therefore the list compiled early in the 19th century by the late Dr. Imray has been revised by this Department with the kind asistance of the Hon. J. C. Macintyre, Mr. A. C. Shillingford, the Hon. A. D. Lockhart, Mr. G. Downing, and Dr. H. A. Alford Nicholls, C.M.G., F.L.S., in Dominica.

This list gives some scientific identifications of the trees that have already been made and some details of their various uses. The principal corrections and additions have been put in square brackets under the initials of the authorities for them.

1. ACACIA (*Acacia farnesiana*).

Wood employed for posts, being very durable in the ground; cabinet wood; the husks of the pods are pounded and boiled in water, and this decoction is rubbed on leather to colour it black.

2. ACAJOU.

Cabinet wood. [The same as Red Cedar (*Cedrela odorata*); an excellent wood for furniture. (J. C. M.)]

3. ACAJOU BLANC.

Tree about 3 or 4 feet in diameter: makes excellent boards for inside house work. [Commonly known as Bois Blanc or Montagne. (J. C. M.) It can only be used for inside work. (G. D.)]

4. ACAJOU GRANDE FEUILLE (*Guarea* sp.).

Large tree; timber employed for all kinds of inside house work.

5. ACAJOU MONTAGNE.

Large tree 2 to 3 feet in diameter; employed for house-building, furniture wood, shingles; not very hard, but bears moisture well.

6. ACAJOU NOUVEAU.

Tree nearly 3 feet in diameter; sawn into boards and planks for general use, shingles, and furniture.

7. [ACAJOUMA FALAISE. (G. D.)]

[A hard, red-wood tree, 12 to 14 inches in diameter. It makes good scantling. (G. D.)]

8. ACOMAT BLANC.

Tree 3 or 4 feet in diameter: employed for house work, posts, rafters, etc.; only used for inside work. [Commonly known as Bois hete or Acomat hete. (J. C. M.)]

9. ACOUQUOI GRIS.

Large tree; employed for house and garden posts, and may be used for rafters, beams, etc.

10. ACOUQUOI JAUNE.

Tree from 2 to 2½ feet in diameter: valuable wood, used for all purposes, inside and outside work; furniture wood.

11. ADEGON (*Ardisia* sp.).

Large tree 4 or 5 feet in diameter; useful for all purposes; boards, planks, mill work, house work, ship-building, shingles; lasts well in water.

12. AMANDIER [OR NOYEAU (H.A.A.N.)] (*Prunus occidentalis*).

Large tree 3 or 4 feet in diameter; sawn into boards and planks, used for mill work and inside house work, also for furniture wood; the seeds are used for making the liqueur 'Noyeau;' the bark is sometimes put into rum to give it a flavour.

13. ANGELIN (*Andira inermis*).

Large tree; employed for all kinds of house work, inside and out; for mill work, rollers, etc.; valuable timber, lasts well in water.

14. ARALI (*Clusia* sp.).

Tree makes excellent posts: lasts long in the ground. [The timber of this tree is not very durable. It is used for posts because it grows rapidly. (J. C. M.) It makes excellent coke. (G. D.)]

15. BALATE.

Large hardwood tree 3 to 5 feet in diameter; the wood is dense and tough, and is valuable for mill rollers and frames, plates, beams, etc., and for inside house work; does not stand water well. [The fruit is edible and is much appreciated. It is often sold on the market. (A. D. L.)]

16. BLACK CINNAMON OR BOIS D' INDE (*Pimenta acris*).

Large tree about 4 feet in diameter; one of the hardest and heaviest woods the island produces; very durable, good for rollers and other mill work, especially cogs, posts in the ground, sills, etc. The leaves are used for making bay rum, and large quantities of the dried leaves are exported to the United States.

17. BOIS AFFIE (*Freziera undulata*).

Large tree; sawn into planks and boards for general use; gun stocks are made of this wood.

18. BOIS ANGLAIS.

Large tree; timber used for ordinary purposes, shingles, posts, rafters, etc.

19. BOIS BAMBARRA (*Diospyros* sp.).

Large tree 4 to 5 feet in diameter: wood tough and strong, employed for oars, mortar pestles, etc.; and may be used for inside house work. The fruit is poisonous. It is used to kill fish. (A. D. L.)

20. BOIS BLANC OR MONTAGNE.

Tree 3 feet in diameter; used for inside and outside house work. Used for making shingles for the sides of houses.

21. BOIS BOUELE.

Small tree; pretty cabinet wood; useful for house and garden posts, rafters, etc.

22. BOIS BOUIS CHIEN (*Chrysophyllum microphyllum*).

Timber tree; makes good boards, planks, posts: used for all kinds of inside work; made into shingles; furniture wood.

23. BOIS BANDE (*Chione glabra*).

Large hardwood tree; rollers for small cattle mills are made of this wood; all kinds of mill and house work, especially inside work.

24. BOIS CHANDALLE (*Amyris balsamifera*).

Small tree; used for posts and for making flambeaux.

25. BOIS CHARAIBE (*Sabinea carinalis*).

Small tree; used for posts, and fancy cabinet wood.

26. BOIS CARRE.

Small tree; adapted for fancy cabinet wood.

27. BOIS CARRIERIE. Timber used for ordinary purposes.

28. BOIS CICEROU OR PIPIRIE (*Pithecolobium micradenium*).

Large timber tree; made into staves and shingles boards, planks. [This tree is also called Savonette but must not be confounded with the Soap-berry tree (*Sapindus inaequalis*), also called Savonette. (J. C. M.) The true Savonette is *Lonchocarpus violaceus*.]

29. BOIS CONTREVENT. [*Lucuma multiflora* (H.A.A.N.)]

Valuable hardwood tree fully 4 feet in diameter; employed for mill rollers, frames, etc., furniture wood, sideboards beds, etc.; house-building.

30. BOIS COTE.

Large tree; very good timber; employed for all kinds of house work, posts, etc.

31. [BOIS COTLETTE. [*Citharexylum quadrangulare* (H. A. A. N.) (G.D.)]

[A medium-sized tree, the wood of which is used for inside house work, both as boards and scantling. (G. D.)]

32. BOIS DEBASSE (*Myrcia ferruginea*).

Tree about 18 inches in diameter; employed for house posts and rafters.

33. BOIS DECREE [OR BOIS DORE, (H. A. A. N.)] (*Morisonia Imrayi*).

Large tree; timber used for ordinary purposes and cabinet work.

34. BOIS DE FER BLANC, BOIS DE FER NOIRE.

Tree 12 to 18 inches in diameter: very durable wood; used for posts. Also for cabinet work.

35. BOIS DIABLE (*Licania hypoleuca*).

Very hard, tough wood: useful in house-building: makes the best charcoal: used for making flambeaux: does not stand moisture.

36. BOIS D'ORME (*Guazuma ulmifolia*).

Tree 2 to 3 feet in diameter: sawn into boards, useful for oars, posts, staves, etc. [Generally used for spars. (J. C. M.)]

37. BOIS DUBARRE.

Hardwood tree: used for posts, rafters, beams, etc.: also for mill work.

38. BOIS FLEUR JAUNE (*Tecoma stans*).

Small tree: employed for inside house work.

39. BOIS GOUMME.

Large tree: timber used in house-building.

40. BOIS GRAINE BLEUE (*Symplocos martinicensis*).

Tree about 2 feet in diameter: sawn into boards and planks, and used for inside house work. [Also known as Bois Martinique. (G. D.) The timber is very inferior and is rarely used (J. C. M.), but can be used for inside posts and rafters (G. D.)]

41. BOIS GRAINE ROUGE.

Large tree: boards used for inside and outside work: heading for sugar hogsheads.

42. BOIS HYPOLITE.

Tree from 2 to 3 feet in diameter: made into posts, shingles, rafters, etc.

43. BOIS L'ILL (*Cassipourea elliptica*).

Tree 2 feet in diameter: used for posts, rafters, etc., and in house-building; might be used in cabinet work.

44. BOIS LAIT (*Ficus* sp.).

Tree about 2 feet in diameter: used for house posts and rafters: may be sawn into boards for inside work.

45. BOIS LEDAT.

Timber may be used for ordinary purposes.

46. BOIS LEZARD (*Vitex divaricata*).

Large and lofty tree: one of the best and most lasting woods for house-building: used for making shingles, posts in the ground, mill posts, etc.: durable in water. [Used for making staves for vats. (A. D. L.)]

47. BOIS LONG (*Freziera* sp.).

Large tree, 3 or 4 feet in diameter, employed for shingles and posts.

48. BOIS MAMMIE.

Tree 2 to 3 feet in diameter, used for boards and fences, also in house-building, inside and out: lasts well in water.

49. BOIS MANIOC.

Tree 2 to 3 feet in diameter: timber used in house-building, inside and out: lasts well in water.

50. BOIS MARBRE (*Ardisia* sp.).

Small tree: pretty cabinet wood.

51. BOIS MASSE.

Tree 12 to 18 inches in diameter: timber used for house work and cabinet making, also for mallets: wood tough.

52. BOIS PERDRIX.

Small tree; wood tough, and used as handles for hoes, axes, and other tools: also very pretty cabinet wood.

53. BOIS PETITE FEUILLE ROUGE, BOIS PETITE FEUILLE BLANCHE.

Large trees, 3 or 4 feet in diameter: used for boards, posts, and shingles; durable wood, lasting in water.

54. BOIS PIN (*Talauma Plumieri*).

Large tree: boards used for inside house work.

55. BOIS PIQUETTE (*Ixora ferrea*).

Wood hard and tough: used for axe handles, posts, and for making flambeaux: lasting in the ground.

56. BOIS PISTOLET (*Guarea Perrotteti*).

Large tree 3 or 4 feet in diameter: valuable furniture wood, used in inside and outside work.

57. BOIS RASSADE BLANC.

Used for same as Bois rassade rouge.

58. BOIS RASSADE ROUGE.

Tree 2½ feet in diameter; used for posts and rafters; may be sawn into boards and planks.

59. BOIS RIVIERE (*Chimarrhis cymosa*).

Large tree: timber used for indoor work, furniture wood.

60. BOIS SAND ROUGE, BOIS SAND BLANC.

Tree 2 to 3 feet in in diameter: sawn into boards for inside and outside house work: shingles.

61. BOIS SERPENT.

Tree 3 to 4 feet in diameter; useful timber for any purpose—shingles, posts, oars, house-building, mill frames, rafters, etc.

62. BOIS SOPHIE [*Acacia spicata* (H. A. A. N.)]

Small tree; durable for posts, fancy cabinet wood.

63. BOIS TAN (*Brysonima* sp.).

Tree about 2 feet in diameter: wood tough and light; made into beams, rafters, posts, oars; bark used for tanning.

64. BOIS DE VIN [OR MORICYPRE ROUGE (H. A. A. N.)]

Large tree; timber employed for inside house work.

65. BOIS VINETTE.

Small tree; used for posts, and making flambeaux.

66. BOIS VIOLIN (*Guatteria* sp.).

Tree about 2 feet in diameter; the boards and planks are available for inside house work; wood does not last in the ground; used for spars, oars, staves: wood light.

67. BOUIS (*Chrysophyllum glabrum*).

Large tree about 4 feet in diameter; timber employed for mill frames and rollers, house work, posts, etc.; wood not very hard but durable.

68. BOUIS FOURMI (*Ilex* sp.).

Large tree; sawn into boards and planks; employed for all inside work, posts, etc.

69. BRISIETTE.

Middling-sized tree; sawn into boards and planks, and employed for inside house work; very good furniture wood; chairs and tables are made of it. [The wood is very hard, and can rarely be used for boards. (A. D. L.)]

70. BULLY TREE OR BALATA [*Bumelia retusa* (H. A. A. N.)]

Very large and valuable timber tree, attains a diameter of 6 or 7 feet; used for all kinds of mill work, rollers, beams, water and balance wheels, sills, cogs, plates, etc., also applied to house work. [Also called Bullet tree, from the appearance of the green fruit. (A. D. L.)]

71. CACAO MARRON.

Tree about 2 feet in diameter; used in house-building and for shingles. [Very little, if any, value as timber. (J. C. M.)]

72. COCONIER (*Ormosia dasycarpa*).

Large tree 3 or 4 feet in diameter: useful wood for all kinds of house work, inside and out; rafters, posts, etc. [Makes excellent shingles. Almost equal in durability to wallaba. (G. C. M.)]

73. CAFE MARRON (*Faramea odoratissima*).

Small tree used for posts, rafters, plates, etc., in house-building.

74. CAFE MARRON ROUGE.

Employed for same purpose as Café Marron; good for posts and in house-building.

75. [CALUMITE. (G. D.)]

[Useful timber for house work and scantling. Also for mill frames, as it is durable and lasts well in water. (G. D.)]

76. CARAPATE.

Tree about 2 feet in diameter; used for rafters, beams, posts, etc.

77. CARAPITE.

Large tree 3 or 4 feet in diameter, employed for mill work of all kinds, and for house work.

78. CEDAR (*Cedrela odorata*).

Large tree; an excellent furniture wood; the odour repels insects; used for house and ship-building. [Also known as Red Cedar and Acajou.]

79. CHATAIGNIER CACAO.

Valuable timber; employed for mill rollers, posts, etc.

80. CHATAIGNIER GRANDE FEUILLE (*Sloanea Massoni*).

Large tree 5 or 6 feet in diameter; timber used for mill rollers, inside house work; becomes hard when dry.

81. CHATAIGNIER NOIR [*Trichilia diversifolia* (H. A. A. N.)]

Tree 2 or 3 feet in diameter; sawn into boards and planks, used in house-building and for mill rollers.

82. CHATAIGNIER PETITE FEUILLE (*Sloanea* sp.).

Used as the above species of Chataignier.

83. CITRONELLE.

Tree 1 foot in diameter; used for house posts—small work.

84. COMMENTIN (*Myrcia divaricata*).

Hardwood tree; employed for beams, rafters, posts, etc. The Caribs mix the expressed juice of the bark with Roucou, for the purpose of colouring and polishing other woods.

85. COURBARIL, OR LOCUST TREE (*Hymenaea Courbaril*).

Valuable timber tree of large size; wood dense and close-grained, used for making all kinds of furniture: formerly employed in house-building, now too valuable for that purpose; resembles mahogany, but is much harder; not durable in the ground.

86. EPINEUX BLANC.

Large tree sawn into boards and planks, employed in house work, inside and out, rafters, posts, etc.,: cabinet work.

87. EPINEUX PETITE FEUILLE [*Zanthoxylum microcarpum* (H. A. A. N.)]

Small tree, durable wood for posts.

88. EPINEUX ROUGE (*Zanthoxylum ochroxylum*).

Small tree, good for posts; lasting in the ground; available for fancy cabinet work.

89. FIGUER PETITE FEUILLE (*Ficus lentiginosa*).

Timber used in house-building; the wood is soft and not durable.

90. [FROMMAGER, OR SILK COTTON (*Eriodendron anfractuosum*) (G. D.)]

[Large tree, used for canoe shells. The silk cotton which envelopes the seeds is used for stuffing pillows. Under the name of Kapok it is largely exported from Java to Holland. (G. D.)]

91. GALBA (*Calophyllum Calaba*).

Lofty tree 4 or 5 feet in diameter; timber valuable for mill rollers, frames and other mill work: pretty cabinet-making wood very durable; lasts well in the ground, bears exposure to moisture. [Wood also used for cart felloes.]

92. GOMMIER (*Dacryodes hexandra*).

Probably the largest and loftiest tree the island produces; nearly all the canoes of the island are made of this wood,

A whitish resinous substance exudes copiously from the trunk of the tree; this resin* is much used in making flambeaux, also in the Roman Catholic places of worship as incense. [There are two distinct varieties of the forest Gommier (*Dacryodes hexandra*), known as Gommier blanc and Gommier rouge. The latter is also known as Naucent, and yields a much larger quantity of gum than the Gommier blanc. The gum used in making flambeaux is equally got from Gommier blanc, while that used for incense is exclusively obtained from Gommier rouge. (J. C. M.) The lowland Gommier rouge is *Bursera gummifera*.]

93. [GOMMIER ROUGE, OR LOWLAND GOMMIER (*Bursera gummifera*). (G. D.)]

[Tree grows to about 18 inches in diameter. It is used for inside work. Also for boards and posts. Green posts, cut and put into the ground for fencing, take root and grow readily. (G. D.)]

94. GOMBO MONTAGNE.

Tree 3 feet in diameter; sawn into boards and used for house-building.

95. GOYAVIER (*Eugenia aeruginea*).

Tree about 2 feet in diameter: light wood, used for inside house work, rafters, posts, plates, etc.

96. GOYAVIER DOUCE.

Large tree; employed for mill work, house posts, beams, etc.; used only for inside work: not lasting in the ground.

97. GOYAVIER MONTAGNE.

Middle-sized tree; timber used for mill work.

98. GREENHEART (*Nectandra Rodiaei*).

Valuable timber tree, employed for mill work, etc.; very pretty cabinet wood.

99. GROSETTIER.

Large tree, 8 feet in diameter; used for making posts, beams, rafters, etc.; may be sawn into planks and scantling.

100. GUAVA (*Psidium Guajava*).

The wood of the guava is very tough, and is employed as handles for hoes, axes, etc., like the tamarind wood. The fruit makes excellent jelly.

101. GUEPPOIS.

Small tree used for making walking sticks, and for posts in the ground, being very durable.

102. GUEPPOIS GRANDE FEUILLE.

Small tree used for posts and walking sticks.

103. ICACQUE (*Hirtella triandra*).

Small tree; wood used for inside and outside work.

104. ICACQUE MONTAGNE.

Small tree; wood used for posts, plates, rafters, etc.

* Gommier resin has been submitted to manufacturers of printing inks and to varnish makers, who both reported that the soft gommier resin would answer their purposes as well as gum elemi. It would have to be exported in a fresh and clean condition to command good prices. (See *Agricultural News*, Vol. III, p. 155.)

105. KAKLIN [*Clusia venosa* (H. A. A. N.)]
Hardwood tree, 12 to 16 inches in diameter; durable wood for house work, posts, etc.; lasts well in water; makes excellent charcoal.

106. KREKE PETIT KREKE (*Melastoma* sp.).
Small tree; wood soft and of little value; used for posts in house-building.

107. [LABRICOT. (G. D.)]
[A good-sized tree. Timber used in house work, inside or outside, both as boards and as scantling. (G. D.)]

108. [LAGARON. (G. D.)]
[A tree 16 to 18 inches in diameter. The wood is hard and lasts well in water. It is used for scantling, inside or outside work, and for mill framing and rollers. (G. D.)]

109. LA GLUIE, OR BOIS DE SOIE [*Sapium aucuparium* (H. A. A. N.)]
Middle-sized, but sometimes grows to a very large tree. [The timber is inferior and is only occasionally used for inside work. (J. C. M.) It is not used for building purposes. (G. D.)]

110. LAURIER-AVOCAT (*Aydendron* sp.).
Small tree; light wood, employed for shingles, posts, rafters, etc.

111. LAURIER BLANC.
Useful wood, made into boards, planks, rafters, etc.

112. [LAURIER BORD DE MER (H. A. A. N.)]
[Lofty tree 12 to 18 inches in diameter. Used for shingles, boards, etc. (H. A. A. N.)]

113. LAURIER CALIBRE.
Tree 2 feet in diameter, made into shingles, planks, etc.

114. LAURIER CANELLE [*Aydendron sericeum* (H. A. A. N.)]
Tree 2 to 3 feet in diameter; excellent timber; made into boards, planks, rafters, etc., and may be used for any purpose.

115. LAURIER CYPRE [*Ocotea* sp. (H. A. A. N).]
Tree 2 to 4 feet in diameter; the timber is used for all kinds of work, inside and out. [The boards are generally used for inside house work. It resembles white cedar. (G. D.)]

116. [LAURIER DE VIN (G. D.)]
[This is a large tree, the wood of which is useful for boards and scantling, and for inside work. (G. D.)]

117. LAURIER FALAISE.
Tree about 18 inches in diameter; the timber is used for inside work.

118. LAURIER FETIDE.
Tree 2 to 4 feet in diameter; used for the same purposes, and of equal good quality as the Laurier Canelle.

119. LAURIER ISABELLE (*Ocotea* sp.).
Small tree; wood hard; used for posts and shingles, and sawn into boards; cabinet wood. [Also called Bois de mer. It resembles Laurier Marbre, and is used for boards and planks, furniture and shingles. (G. D.)]

120. LAURIER JAUNE.

Small tree; employed for boards, shingles, and ordinary purposes.

121. LAURIER MADAME [*Nectandra sanguinea* (H. A. A. N.)]

Large tree; good timber: used for planks, beams, posts, rafters, cabinet work.

122. LAURIER MANGUE.

Tree 3 feet in diameter; used for inside and outside house work.

123. LAURIER MARBRE.

Tree 2 to 3 feet in diameter; sawn into boards and planks; furniture wood; shingles.

124. LAURIER MUSCAT.

Tree about 3 feet in diameter: made into boards, shingles, and rafters; used for inside and outside work; furniture wood.

125. LAURIER NOIR.

Small tree; makes planks, and boards. [Shingles made of this wood rapidly decay. (G. D).]

126. LAURIER PAIN.

Tree 2 to 3 feet in diameter; good timber; used for shingles, planks, and all kinds of house work.

127. LAURIER REGLISSE.

Tree about 18 inches in diameter; used for posts, rafters, plates, etc.

128. LAURIER RIVIERE.

Tree about 4 feet in diameter; grows large in water; timber used for all kinds of inside and outside house work, also for shingles.

129. [LILAC (G. D.) [*Melia sempervirens* (H. A. A. N.)]

[A tree 10 to 12 inches in diameter. Lasts in water and makes good posts. It is also used in house work, but does not make good boards. (G. D.)]

130. LOGWOOD OR CAMPECHE (*Haematoxylon campechianum*).

Dye-wood: used for posts; very durable cabinet wood.

131. MAHOE-COCHON [*Sterculia caribaea* (H. A. A. N.)]

Large tree 3 to 4 feet in diameter; used for staves and boards; wood splits very easily.

132. MAHOE-PIMENT (*Daphnopsis tinifolia*, Meissn.).

Small tree; used for posts: wood of little value: bark employed for making rope.

133. MANGUE BLANC (*Moronobea coccinea*).

Large and lofty tree; valuable timber; may be sawn into planks and boards for ordinary use, and makes excellent staves. [Also known as Mangue Jaune. It yields good timber for inside work, but when exposed to weather the wood is not durable. It is sometimes used for shingles, but these do not last well. (J. C. M.)]

134. MANGUE-ROUGE [*Tovomita Plumieri* (H. A. A. N.)]

Tree about 12 to 18 inches in diameter; the best wood of

the country for staves and for sugar hogsheads; almost equal to the red oak staves. Makes very durable shingles called Dominica wallaba.

135. MAPOU (*Cordia reticulata*).

Wood sometimes employed for making staves. [The timber from this tree is of little value. (J. C. M.) This tree is most injurious to cultivation, as it is the principal host of mistletoe. (A. D. L.)]

136. MAPOU GRANDE FEUILLE [*Cordia sulcata* (H.A.A.N.)]

Sawn into planks for house-building; staves.

137. MAPOU PETITE FEUILLE.

Wood used for staves.

138. MASTIC OR ACOMAT [*Sideroxylon Mastichodendron* (H. A. A. N.)]

Very large tree, reaches to 6 feet in diameter; used for mill work and in house-building; available for almost every kind of work; one of the most valuable woods in the island. [Usually known as Acomat St. Christophe. (J. C. M.)]

139. MILLE BRANCHES.

Large hardwood tree; employed for mill rollers and other mill work.

140. MOIS MAT.

Middle-sized tree; makes good masts for vessels, also oars, spars, and staves.

141. MORICYPRE (*Byrsonima spicata*).

Tree about 2 feet in diameter; useful timber for house-building and cabinet work. [Commonly known as Moricypre blanc. (J. C. M.)]

142. OLIVIER (*Terminalia Buceras*).

Very large tree; timber valuable; made into boards and planks, used for all work (inside and out); very durable in water; the wood is difficult to ignite and does not flame; one of the best woods for shingles.

143. ORANGE MONTAGNE.

Timber used in mill work, house posts, beams, and rafters. [Known as Toranger. (G. D.)]

144. PETIT BAUME.

Small tree; used for posts, wattles, etc., and for making flambeaux, etc.

145. PETIT BOUIS.

Tree about 1 foot in diameter; very durable wood, available for posts, rafters, beams, etc.

146. PETIT CITRON. CHENE DU PAY (*Ilex cuneifolia*).

Tree 18 inches in diameter; very useful wood, employed for all kinds of house work, rafters, sills, posts, cart felloes; makes excellent oars.

147. PIN D' EPICES. [*Lucuma mammosa* (H. A. A. N.)]

Large tree; employed for mill work, rollers, etc., and sawn into boards for indoor work. [It is not customary to use this wood for boards, as it is too hard. (G. D.)]

148. [PISTOLET PETITE FEUILLE. (G.D.)]

[A large tree. The wood is durable. It is used for house work, and for boards and scantling. Also a cabinet wood, D. G.)]

149. POIRIER MONTAGNE (*Exostemma caribaeum*).

Small tree; used for posts and for making flambeaux; pretty cabinet wood; durable.

150. POIS DOUX (*Inga laurina*).

Small tree; makes excellent charcoal; employed as posts for cane trash house, and other coarse work. [The wood does not last well; it is subject to borer when cut. (G. D.)]

151. POIS DOUX MARRON (*Inga ingoides*).

Middle-sized tree; used for stavês, sawn into boards and planks, and employed for indoor work only. [The wood is not particularly valuable for building purposes. (G. D.)]

152. POIS DOUX MARRON BLANC.

Tree 3 or 4 feet in diameter; cut into staves and shingles, difficult to saw into planks. [The wood is 'stringy,' and inferior. (G. D.)]

153. POMME ROSE (*Eugenia Jambos*).

Tree about 18 inches in diameter; the young branches are employed for making hoops for sugar hogsheads; fruit tree.

154. POMMIER.

Large tree, 4 to 5 feet in diameter; employed for staves, rafters, and inside house work: not a durable wood.

155. QUINA (*Exostemma floribundum*).

Small tree; used for posts and rafters: the bark of this tree is possessed of tonic and emetic properties, and is used in the country medicinally.

156. RAGIGOND.

Large tree; timber used for inside house work.

157. RAISI MONTAGNE.

Tree 2 feet in diameter; used for light work in house-building; not durable.

158. REINETTE.

Small tree; used for house and garden posts, for mill work, rollers, etc., and sawn into boards for indoor work.

159. RESINIER GRANDE FEUILLE (*Coccoloba latifolia*).

Large tree nearly 4 feet in diameter; dense, close-grained wood, valuable timber, employed in all kinds of house and mill work; one of the most durable woods of the island; becomes hardened by age, so that tools can scarcely work it; almost indestructible in the ground. [This tree rarely attains a diameter of more than 2 feet. (J. C.M.)]

160. RESINIER PETITE FEUILLE (*Coccoloba* sp.).

Tree 2 to 3 feet in diameter; very durable in the ground; used for posts, etc.

161. ROSEWOOD (*Cordia gerascanthoides*).

Tree 2 feet in diameter, employed for all kinds of house

work, ship-building, and in furniture. [Known also as Boîs de Rose (J. C. M.), or Laurier de Rose. (G. D.) It can be used for house and cabinet work. (G. D.)]

162. [SAGLUIE. (A. D. L.)]

[A very tall, upright tree. The wood is tough and is suitable for building up canoe shells. It also forms excellent boards for heads of casks. The latex obtainable from this tree is used for bird lime. (A. D. L.)]

163. SATIN WOOD, YELLOW SANDERS, OR NOYER. (*Buchenvia capitata*).

Large tree ; beautiful and valuable wood, becoming scarce in the country ; now chiefly used as a furniture wood ; formerly in house-building and mill work ; very durable in the ground.

164. SAVONETTE (*Lonchocarpus violaceus*).

Good-sized tree, 2 feet in diameter ; valuable timber ; available for many purposes, mill rollers and mill work in general, posts, beams, cart naves, and felloes, blocks for pulleys, ship and boat-building.

165. SEASIDE GRAPE (*Coccoloba uvifera*).

Tree about 2 feet in diameter ; timber used chiefly for boat-building.

166. [SEPTAUS. (A. D. L.)]

[A large red-wood tree used for making boards .(A. D. L.) This wood is useful for all inside work, but will not last when employed for outside work. It splits easily. (G. D.)]

167. SICAH, OR ABRICOT MARRON.

Tree about 2 feet in diameter, and employed for inside and outside work, posts, sills, plates, beams, etc.

168. SIMARAUBA (*Simaruba amara*).

Tree 3 to 4 feet in diameter ; timber used for inside house work, heading for casks ; used medicinally : also known as quassia wood.

169. SOAP BERRY (*Sapindus inaequalis*).

Timber used for ordinary purposes. [Sometimes called Savonette. (J. C. M.)]

170. SUYEAU.

Small tree ; used for house posts : not of value.

171. SUYEAU MONTAGNE (*Turpinia occidentalis*).

Large tree ; sawn into boards and planks ; used for ordinary purposes.

172. TAMARIND (*Tamarindus indica*).

The wood of the tamarind tree is tough and elastic, and is applicable for handles to axes, hoes, and other tools ; the preserved fruit is an article of commerce.

173. TAMARIND MONTAGNE.

Small tree ; used for posts and palings, also sawn into boards ; lasts well in water.

174. TENDRE AGAILLOUX. (*Sabinea carinalis*).

Small tree; pretty cabinet wood, very durable in the ground as posts.

175. WHITE CEDAR OR POIRIER (*Tecoma leucoxylon*).

Large tree; timber employed for inside and outside house work, also in ship-building; lasts well in sea-water. Used for making shingles, boards, scantling, etc. There are two varieties. The trunks of the one growing on the Eastern side of the island are useful for piles for jetties.

176. [ZAMAN OR ALMOND. (*Terminalia catappa*). (G. D.)]

[A large tree. The wood is durable, lasts in water and is used in house work as boards and scantling. (G. D.)]

LIST OF WOODS SUITABLE FOR CABINET WORK.

Local Name.	*Botanical Name.*
Acajou	
Aconquoi Jaune	
Angelin	*Andira inermis.*
Bois bouele	
Bois bouis chien	*Chrysophyllum microphyllum.*
Bois contrevent	
Bois decree	*Morisonia Imrayi.*
Bois de fer blanc or White Ironwood	
Bois de fer noir or Black Ironwood	
Bois l'ill	*Cassipourea elliptica.*
Bois marbre	*Ardisia* sp.
Bois masse	
Bois perdrix	
Bois pistolet	
Bois riviere	*Chimarrhis cymosa.*
Bois sophie	*Acacia* sp.
Bois tan	
Brisiette	
Coconier	*Ormosia dasycarpa.*
Cedar or Red Cedar	*Cedrela odorata.*
Courbaril or Locust tree ...	*Hymenaea Courbaril.*
Galba	*Calophyllum Calaba.*
Logwood or Campeche ...	*Haematoxylon campechianum.*
Mastic or Acomat St. Christophe	*Sideroxylon Mastichodendron.*
Olivier	*Terminalia Buceras.*
Petit citron	*Ilex cuneifolia.*
Poirier montagne	*Exostemma caribaeum.*
Rosewood	*Cordia gerascanthoides.*
Satin wood	
Tendre acailloux	
Tamarind	*Tamarindus indica.*

LIST OF WOODS SUITABLE FOR CART WORK.

Local Name.	*Botanical Name.*	*Remarks.*
Balata or Bully tree	*Bumelia retusa.*	For frames and spokes.
Cedar, white ...	*Tecoma leucoxylon*	For felloes and riders.
Courbaril or Locust tree .. .	*Hymenaea Courbaril.*	For naves.
Galba	*Calophyllum Calaba.*	For fellows, riders, and tongues.
Savonette	*Lonchocarpus violaceus.*	For naves.
Yellow sanders	*Bucida capitata.*	For naves.

LIST OF WOODS SUITABLE FOR COOPERING WORK.

Bois blanc or Montagne ...		For staves.
Mahot-cochon ...	*Sterculia caribaea.*	For staves.
Mangue blanc ...	*Moronobea coccinea.*	For staves.
Mangue rouge ...	*Tovomita Plumieri.*	For staves.
Petit citron ...	*Ilex cuneifolia.*	For headings of packages to contain liquids.
Pois doux marron .	*Inga ingoides.*	For staves.

LIST OF WOODS SUITABLE FOR GENERAL PURPOSES.

(Exposed to weather.)

Local Name.	*Botanical Name.*	
Angelin	*Andira inermis.*	
Balata or Bully tree .		
Black cinnamon or Bois d'Inde	*Pimenta acris.*	
Bois lezard	*Vitex divaricata*	
Mastic or Acomat St. Christophe .	*Sideroxylon Mastichodendron.*	
Yellow sanders . .	*Bucida caribaea.*	
Resinier grande feuille .. .	*Coccoloba latifolia.*	obtainable only in short lengths.
Savonette	*Lonchocarpus violaceus.*	obtainable only in short lengths.
Tendre acailloux .. .		

LIST OF WOODS SUITABLE FOR HOUSE WORK

(General.)

Local Name.	*Botanical Name.*
Besides all the various Lauriers, ...	
Acajou	
Acajou blanc	
Acajou grand feuille... ...	*Guarea* sp.

LIST OF WOODS SUITABLE FOR HOUSE WORK.—(*Concluded.*)

Acajou montagne	... ...	
Acajou nouveau	.. ...	
Adegon...	... ...	*Ardisia* sp.
Amandier	... .	*Prunus occidentalis.*
Bois affle	... .	*Freziera undulata.*
Bois ciceron or pipirie	...	*Pithecolobium micradenium.*
Bois contrevent	... ...	*Lucuma multiflora.*
Bois mammie ...	... ...	
Bois riviere	... ...	*Chimarrhis cymosa.*
Bois tan	... ...	*Brysonima spicata.*
Bois violin	... ...	*Guatteria* sp.
Brisiette	... .	
Cedar, red	.. .. ..	*Cedrela odorata.*
Cedar, white ...	... ...	*Tecoma leucoxylon.*
Galba ...	... ...	*Calophyllum Calaba.*
Gommier	... .	*Dacryodes hexandra.*
Moricypre	... ...	*Brysonima spicata.*
Olivier ...	... ...	*Terminalia Buceras.*
Rosewood	... ...	*Cordia gerascanthus.*
Suyeau montagne	... ...	*Turpinia occidentalis*
	(Shingles.)	
Coconier	... ...	*Ormosia dasycarpa.*
Laurier avocat	... ...	*Aydendron* sp.
Laurier noir ...	... ...	
Mangue blanc ...	... ...	*Moronobea coccinea.*
Mangue rouge ...	... ...	*Tovomita Plumieri.*
	(Inside work, Frames.)	
Adegon ..	... .	*Ardisia* sp.
Angelin...	... ...	*Andira inermis.*
Balata or Bully tree ...	...	*Bumelia retusa.*
Black cinnamon or Bois d'Inde	... .	*Pimenta acris.*
Bois bandé	... ...	*Chione glabra.*
Bois contrevent	... ...	
Bois cote	... .	*Myrcia ferruginea.*
Bois debasse	... ...	
Bois dubarre	.. ..	
Bois hypolite	... ...	
Bois lezard	... ...	*Vitex divaricata.*
Bois tan	... ...	*Brysonima* sp.
Coconier	... ...	*Ormosia dasycarpa.*
Carapate	... ...	
Carapite	.. ..	
	(Inside work, Flooring.)	
Cedar, white ...	... ...	*Tecoma leucoxylon.*
Commentin	... ...	*Myrcia divaricata.*
Mastic or Acomat St. Christophe	.. ...	*Sideroxylon Mastichodendron.*
Petit citron	... ...	*Ilex cuneifolia.*
Poirier montagne	... ...	*Exostemma caribaeum.*
Résinier grand feuille	...	*Coccoloba latifolia.*
Savonette	... .	*Lonchocarpus violaceus.*
Tendre acailloux	... ...	*Sabinea crinalis.*
Yellow sanders	... ...	

Inside work. (Flooring.)—(*Concluded.*)

Bois riviere	*Chimarrhis cymosa.*
Coconier	*Ormosia dasycarpa.*
Cedar, white	*Tecoma leucoxylon.*

WOODS SUITABLE FOR BOAT-BUILDING.

(Shells.)

Gommier	*Dacryodes hexandra.*

(Frames.)

Cedar, white	*Tecoma leucoxylon.*
Galba	*Calophyllum Calaba.*

(Planking.)

Cedar, white	*Tecoma leucoxylon.*
Gommier	*Dacryodes hexandra.*
Laurier	All of the several varieties.

THE ALEYRODIDAE OF BARBADOS.

BY C. C. GOWDEY, B. Sc.*

Insects of the family Aleyrodidae are very plentiful in Barbados and, in fact, in all of the islands of the West Indies. Nearly all the species are omnivorous and herein lies the danger of their becoming of considerable economic importance. The adults are found usually on the under surface of the leaves, but the immature stages may be sought for on either surface.

In most cases the identification of the species has been made on the pupa cases, and although in a few cases the adults were caught on their food plants, they were for the most part impossible to obtain.

The descriptions of the species, none of which are new, are the original descriptions wholly or in part re-written and added to.

Specimens of all the stages obtainable were mounted in xylol-balsam after they had undergone the following treatment: The larvae and pupae were dehydrated by placing them in xylol and allowing them to remain therein for from ten to twenty-four hours, and then mounted in Canada balsam. The adults were killed in a cyanide bottle, placed in 35 per cent. alcohol, to which a little ether or chloroform had been added to dissolve the wax from the wings and bodies of the insects, and allowed to remain for at least an hour; then they were passed successively through 50, 75, 85, 95 per cent. alcohol, and absolute alcohol, and lastly through xylol.

* Mr. Gowdey acted temporarily in an honorary capacity as Additional Entomologist to the Imperial Department of Agriculture, and has recently been appointed as Economic Entomologist to the Protectorate of Uganda.

In every case the insects were kept in each reagent for at least one hour before being transferred.

This paper has been prepared at the suggestion of Mr. H. A. Ballou, M. Sc., in whose laboratory at the Imperial Department of Agriculture for the West Indies the work was done and to whom I am indebted for several suggestions. The writer's thanks are also due to Dr. H. T. Fernald, Massachusetts Agricultural College, for bibliographic references.

FAMILY ALEYRODIDAE.

The insects of this family were formerly included in the family Coccidae on account of the superficial resemblance of the immature insects to many species of the Coccid genus *Lecanium*; but, as the adults of both families differ so widely, and because of the presence of the 'vasiform orifice' in the larval and pupal stages, they have been separated. Again, unlike the Coccids, the adults of both sexes of the Aleyrodidae are winged.

Family characteristics.—(a)Adult.—Antennae seven-jointed, the first two joints being rather thickened. Eyes restricted, reniform, or even completely divided. Tarsi two-jointed. Body yellowish, pinkish, or more or less spotted with black. The wings and the body are covered with white powder. (Greek, Aleurodes, meaning flour-like.)

(b) Larval and pupal stages.—In the immature stages, the most distinctive character is the presence of the vasiform orifice, a subovate, semicircular, or triangular opening on the dorsum of the last abdominal segment. The body is covered with an abundant waxy secretion.

LIFE-HISTORY AND HABITS.

There are six stages through which the insect passes in reaching its maturity—the egg, three larval, the pupal, and the adult. Briefly, the life-history is as follows: The eggs are laid singly in circles, the female using her head as the centre of the circle, and her body as radius. The eggs are elliptical in shape, white or pale yellow, more or less covered with wax, pedicelate, the pedicel being a prolongation of the chorion. The larvae hatch in ten to thirteen days, moving about freely in a limited space for from six to ten hours before attaching themselves to the leaves. The young larvae are semi-transparent, convex, having antennae and legs, and usually from seven to nine latero-marginal hairs. As maturity proceeds, the antennae, legs, and latero-marginal hairs are lost, the cuticle becomes darker in colour and thicker in texture. 'Honey-dew' is secreted by the pupae, and in some species the fluid is excreted through blunt tubes on the apex of the lingula. The adults free themselves from the pupa-cases with great difficulty, and when dry the waxy secretion appears. Although the adults have well-developed mouth parts and alimentary canal, it is not believed that they do any feeding. So far as is known at the present time, it is probable that there are at least four broods a year in this region, and perhaps more

TABLE FOR SEPARATION OF GENERA.

This family contains but two genera, which may be separated as follows:—

1. Adults having the veins in both pairs of wings with a distal and basal branch. Extremity of the abdomen of the male provided with a pair of forcep-like appendages. Pupa-case never naked . . . ALEYRODICUS.
2. Adults having only a basal branch to the vein in the anterior wings, but the posterior wings have only a single vein. Larvae elliptical . . . . . . ALEYRODES.

I. ALEYRODICUS, Douglas.

TABLE FOR SEPARATION OF SPECIES.

A. Wings of adults immaculate.

Pupa-case secreting an abundance of white wax with long glassy filaments, ovate or elliptical; operculum concave on caudal margin; lingula broad, distal margin entire. . . . . *cocois*, Curtis.

Somewhat larger than the preceding. Pupa-case elliptical, with larger compound pores than in preceding; operculum indented; lingula narrow, indented . . . *anonae*, Morgan.

B. Wings banded with gray.

Wings with four transverse bands, the third and fourth bands being joined by a longitudinal band. Second band broad as far as cephalic nervure, but interrupted broadly just beyond it. Third band, forked at the cephalic nervure. Fourth band broad and bent inward; in the curve thus formed is a white area having a gray spot... *dugesii*, Cockerell.

1. *Aleyrodicus anonae*, Morgan.

(*a*) Larva.—Colour ochraceous. Shape oval, depressed. Antennae two-jointed; second joint long and annulated. Labium one-jointed, prolonged. Labrum quadrilateral. Mandibular organs short, with the maxillary setae long and fine. Legs short, stout. Tarsus with only one claw. Four lateral, infundibuliform, compound spinnerets on each side, and posterior to these, two more simply constructed and smaller, secreting glands on each side, also one on each side anterior to the first pair of legs. Anus large, with long framework of colon easily distinguishable. Longest diameter 1·25 mm.

(*b*) Adult.—Antennae long, seven-jointed; basal joint short; second, longer; third, very long; fourth and fifth, subequal; sixth and seventh, shorter. Head, inserted. Mesonotum, chitinous, well developed. Scutellum, a pair of pyriform plates. Wings, white, ample, broad; anterior, incumbent, length 3 mm.; posterior, length 2 mm.; strong central nervure bifurcated near the apex; branch nervure proceeding from near the base of the central nervure. Genital organs of female bivalvular, and between the valves is the ovipositor. Genitalia of the male are forcep-like, the penis situated between the forceps. On the last abdominal segment of both sexes are two external processes. Length 2·25 mm.

Habitat.—Barbados, British Guiana, Brazil, Trinidad.

Food plants.—*Anona muricata*, *A. reticulata*, *A. squamosa*, *Ficus*, *Pritchardia pacifica*.

2. *Aleyrodicus cocois*, Curtis. (Plate I, figs. 7, 8, 9, 10.)

This species was collected by Sir Robert Schomburgk on cocoa-nut in Barbados and sent to Mr. J. Curtis, by whom it was described under the name of *Ruricola* in the *Gardeners' Chronicle* for May 1845.

Description.—(*a*) Egg.—Length 0·20 mm.; width 0·11 mm. The pedicel has its origin on the side, its length being about 0·064 mm.

(*b*) Larva.—Rostrum distinct, one-jointed, with three protruding filaments. Antennae, six-jointed ; the first joint is stout and about one-fifth as long as joints two and three together. Each ventral abdominal segment bears a transverse row of eight small tri-cellular secretory pores. Dorsal anal pore large and distinct. The dorsal surface of the body is very finely granulated. As the larva becomes full-grown, it becomes more convex, with a thick coating of wax and glassy filaments. The abdominal segments become very distinct and have a median longitudinal ridge.

(*c*) Adult.—Female.—Colour dull honey-yellow. Eyes darker, large, pyriform. Ocelli, two, large and conspicuous. Antennae six-jointed ; basal joint short, stout ; scape twice as long as the basal joint ; flagellum rugoso-annulate ; third joint more than twice as long as one and two together and equal in length to four, five and six together ; sixth joint with an apical bristle and the other joints with short scattered bristles. Wings large, sub-opaque ; median vein forked at two-thirds wing length ; costa of anterior wing crenulated rather finely at the tip and furnished with long bristles near the edge of the wing ; costa of posterior wing with eight hairs near the base. Legs slender ; posterior tibia with an internal row of bristles ; tarsi two-jointed, and having two large tarsal hooks with median hook-like appendage. Abdomen with six plain tergites, the sixth bearing a curved papilla, but only five visible urites ; the abdomen is bordered with waxy secretions. Ovipositor, acute. Length 2·1 mm.

Male.—Similar to the female with the following differences: There are present two large forficular claspers, almost as long as the entire abdomen. Between the claspers is a short, curved style about one-third the length of the claspers. The fourth urite bears a median papilla. The colour of the abdomen is darker than in the female. Length 2·8 mm.

Habitat.—Barbados, Trinidad, British Guiana, Venezuela, Brazil.

Food plants.—Cocoa-nut, Palms, *Psidium Guajava*.

The specimens collected on *Psidium Guajava* were found to be associated with ants, which were doubtlessly attracted by the waxy secretion. Unfortunately, however, I could not obtain the literature necessary for the determination of these

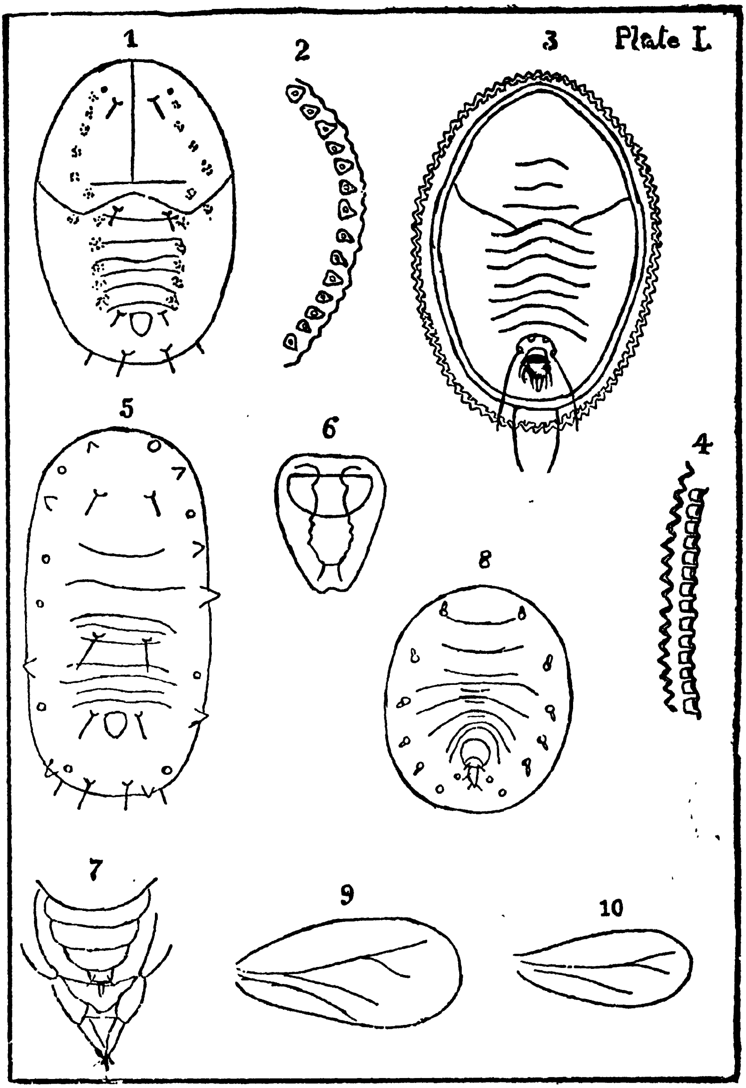

PLATE I. DRAWN BY C. C. GOWDEY.

Fig. 1. *Aleyrodes floridensis*, pupa-case.
Fig. 2. *Aleyrodes floridensis*, margin.
Fig. 3. *Aleyrodes howardi*, pupa-case.
Fig. 4. *Aleyrodes howardi*, margin.
Fig. 5. *Aleyrodes variabilis*, pupa-case.
Fig. 6. *Aleyrodes variabilis*, vasiform orifice, operculum, and lingula.
Fig. 7. *Aleyrodicus cocois*, abdomen of female.
Fig. 8. *Aleyrodicus cocois*, larva, ventral view.
Fig. 9. *Aleyrodicus cocois*, anterior wing.
Fig. 10. *Aleyrodicus cocois*, posterior wing.

ants, but they were probably *Prenolepis longicornis*, as in Trinidad this species is frequently found with *A. cocois*.

3. *Aleyrodicus dugesii*, Cockerell.

Adult.—Colour pale grayish ochraceous, covered with white, mealy substance. Abdomen beneath, shining silvery. Wings white; anterior wings irridescent, marked similarly to *A. ornatus*, but very pale gray and different in detail. There are four gray bands crossing the wings, of which only the third and fourth are joined by a longitudinal band. The basal band bends abruptly inwards after crossing the main nervure, which branches so near the base of the wing that there are practically two nervures, the first gray band failing in the angle between them, but strong again beyond the second. Second gray band broad as far as first nervure, broadly interrupted just beyond it, but continued as a large, nearly circular, gray patch, the greater part of which is above the second nervure, and passing thence as an oblique narrow band to the margin. Third band resembling the second as far as the first nervure, which it meets at the fork; after that failing, but re-appearing strongly a little way down the lowest branch of the nervure and thence passing downwards, becoming very faint. Fourth band broad, passing across the end of the fork, bent inwards, joining the continuation of the third band after the break, and forking at its lower end. The curve of the fourth band leaves a white apical arae in which there is a gray spot. There is also a gray spot at the tip of the second nervure.

Habitat.—Barbados, Mexico.

Food plants.—*Begonia*, *Hibiscus rosa-sinensis*.

II. ALEYRODES, Latreille.

TABLE FOR SEPARATION OF SPECIES.

A. Pupa-case usually but little hidden by secretion; with lateral fringe, i.e., any secretion from marginal wax tubes.
   Pupa-case yellowish, or greenish-yellow. No dorsal secretion. Lateral fringe consisting of only three curling, white filaments. Vasiform orifice small, sub-circular. Adult with immaculate wings. . . *citri*, Riley & Howard

B. Pupa-case hidden by hairy, waxy, or flocculent secretion
   Secretion white and hairy.
      Larva yellowish-green, roundish; ventral surface with five pairs of bristles. Pupa-case with ten to twelve long radiating, star-like wax threads. . . *goyabae*, Goldi.
   Secretion grayish.
      Pupa-case flat, with distinct segments. Vasiform orifice small, sub-cordate, the rim dark-brown, with six or eight spines arising from caudal margin. Dorsum with a pair of setae on first abdominal segment, a pair at vasiform orifice, and a pair at caudal margin extending some distance beyond margin of case. Adult with immaculate wings . . . . *howardi*, Quaintance.

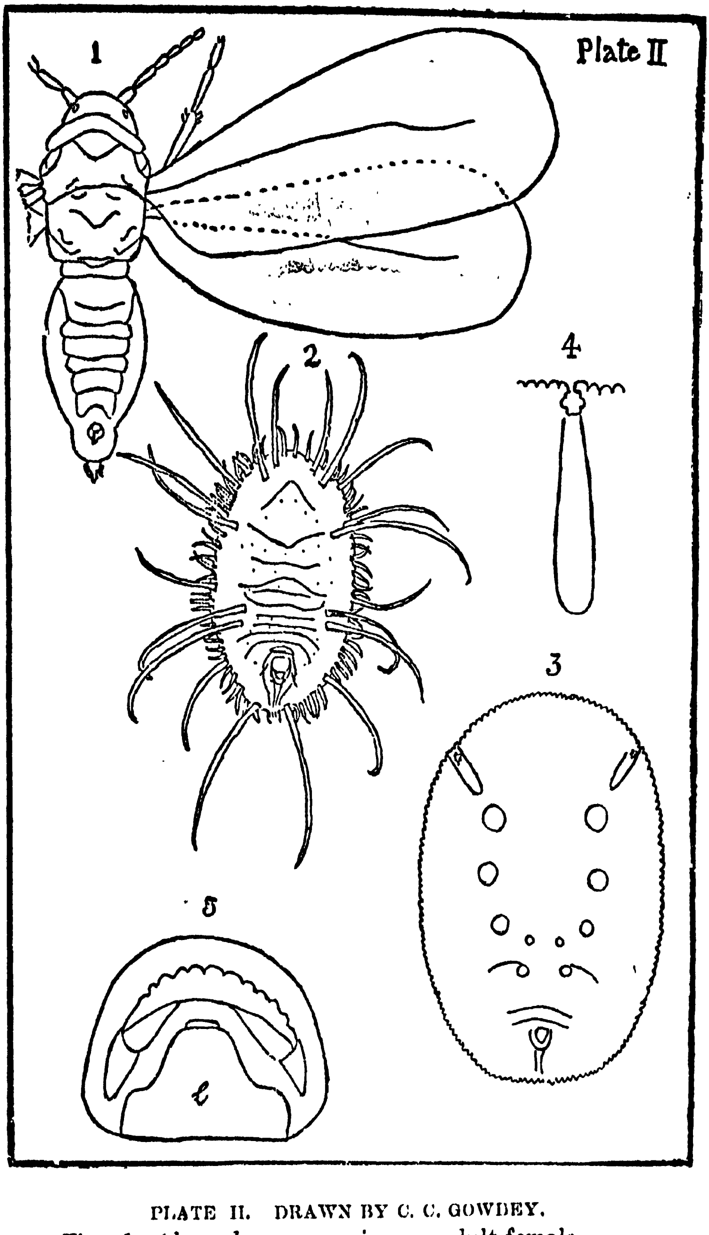

PLATE II. DRAWN BY C. C. GOWDEY.

Fig. 1. *Aleyrodes vaporariorum*, adult female.
Fig. 2. *Aleyrodes vaporariorum*, pupa-case.
Fig. 3. *Aleyrodes citri*, pupa-case.
Fig. 4. *Aleyrodes citri*, groove on pupa-case enlarged.
Fig. 5. *Aleyrodes citri*, vasiform orifice, and lingula (e).

Secretion yellowish, long, hair-like.

Pupa-case light-yellow, elliptical. Vasiform orifice sub-elliptical. Operculum hemispherical, caudal end notched. When denuded, a longitudinal median and sub-marginal secretion on each side of white wax. Adult with immaculate wings. . . . . . . *horridus*, Hempel.

Secretion white, flocculent.

Pupa-case dull yellow, elliptical. Margin conspicuously crenulated. Dorsum with six slender, cylindrical spines. Vasiform orifice twice as broad as long. . *floccosa*, Maskell.

C. Pupa-case yellowish or whitish, and without lateral fringe.

Dorsal secretion a sub-marginal series of glassy, curved, waxen rods from different pores, and a more dorsal secretion of tapering, curved, waxen rods in pairs from large, circular pores.

Pupa-case yellowish, oval to elliptical. Sub-marginal wax tubes short, and blunt. Long dorsal rods present as follows : A pair close to cephalic margin, a pair on cephalic region, a pair on thoracic region, two pairs on abdominal region, a pair at caudal end, and a pair just within margin, from caudo-lateral region. Rostrum reaching nearly to abdomen. Adult with immaculate wings . . . . *vaporariorum*, Westwood.

Dorsal secretion a variable sub-marginal series of glassy, curved rods from distinct pores.

Pupa-case yellowish, elliptical, raised on vertical fringe of white wax. Vasiform orifice, with rounded indenture caudad ; lingula four-fifths length of orifice, with three pairs of lateral lobes and a distal lobe. Adult with immaculate wings. . . . . . . *variabilis*, Quaintance.

Pupa-case marked with brown or black, with a dorsal secretion of wax from distinct pores.

Pupa-case greenish-white, with a row of brown spots on each side. Glassy rods arise from closely set submarginal papillae. . . . . . *floridensis*, Quaintance.

1. *Aleyrodes citri*, Riley & Howard. (Plate II, figs. 3, 4, 5.)

(*a*) Egg.—Colour pale-yellow when first laid, but changes to dark steel-gray or blue as the embryo develops. The red eyes of the embryo are apparent through the shell. Surface of the shell is smooth and shiny. Length 0·2 mm.

(*b*) Larva.—In the first stage, the length of the larva is 0·3 mm. Colour pale greenish-yellow with two darker yellow spots on the dorsum of the abdomen. There are four conspicuously long bristles at the posterior part of the body and six long ones on the anterior end with minute ones along the sides, each arising from a tubercle. Antennae four-jointed. Eyes, four, dark-reddish. Mouth parts consisting of a long, sucking tube. Vasiform orifice subovate, situated on the last abdominal segment. In the second and third moults, the appearance is similar to the first, except in size and minute microscopical characters. In the fourth and last stage, the length is 1·5 mm., and the conspicuous minute bristles have vanished. On the anterior border is a pair of persistent minute

bristles and also a pair on the anal cleft. The dorsum has twelve transverse ridges, indicating the segments. The breathing fold is a distinct ridge on the prothoracic region, extending obliquely outward and forward.

(*c*) Pupa.—Shape broadly oval. Eyes purplish. At the base of the dorsum of the abdomen there is a broad orange spot. Vasiform orifice and ring brown. Transverse ridges on abdomen shorter and less distinct than in the last larval moult. Length 1·5 mm.

(*d*) Adult.—Female.—Colour light orange-yellow. Rostrum tipped with black: eyes reddish-brown in colour, divided by a curved ridge projecting from the cheek. Body is covered with wax, but the ground colour is not obscured. Wings are colourless when newly emerged, but soon become covered with wax. Tarsi two-jointed. Ovipositor short, retractile. Length 1·4 mm. Expanse of wings 2·8 mm.

Male.—The male resembles the female, but is smaller and more slender, and the head and abdomen have heavier tufts of adhering wax. Claspers are slightly curved upward.

Habitat.—Barbados, China, California, Florida, Louisiana, Maryland, Mississippi, Georgia, District of Colombia.

Food plants.—*Citrus* spp. *Melia azedarach*, *Viburnum nudum*, *Gardenia florida*, *Diospyros kaki*, *Prunus caroliniana*, *Quercus aquatica*.

The eggs are deposited by the female on the under surface of the leaves, usually without much order or arrangement, but sometimes they are laid in an arc; in either case the number of eggs deposited varies from fifteen to thirty, and all the eggs are laid within twenty-four hours. The larvae hatch, in this locality, in three to fifteen days. After becoming attached to the leaf the larvae need from twenty to twenty-five days to obtain their full growth; the pupal stage requires ten to twenty days before the adult is ready to emerge. Since this pest requires only from forty-three to sixty days for the completion of its life-history, it is evident that a large number of generations must be produced here in the tropics if conditions, such as climate, food, etc., be favourable, and provided that there are no natural enemies to restrict its multiplication.

In Florida, where this insect is of very great economical importance, the spores of the fungi *Aschersonia aleyrodis* and *Sphaerostilbe coccophila* are being artificially disseminated with excellent results in keeping the Aleyrodid in check.

Any good brand of whale-oil soap will be found effective in killing the white fly. Good's potash Whale Oil Soap No. 3 is safe for tropical use at the rate of 1 lb. of soap to 4 gallons of water.

Fumigation with hydrocyanic acid gas is recognized as one of the most effective methods for destroying this pest, but the cost of fumigating trees, labour included, and not considering the cost of the tents, is equal to the cost of three sprayings. The following amounts have been found effective in Florida for killing this insect:—

Height of Tree in feet.	Water in ounces.	Cyanide C.P. (98%) in ounces.	Sulphuric acid. (66%) in ounces.
8	3	1·5	1·5
10	5	2·5	2·5
12	11	5·0	5·5
16	17	8·0	0·0
20	22	10·0	12·0
20-24	30	14·0	16·0
24-30	34	16·0	18·0
30-36	52	24·0	28·0

Dr. E. W. Berger, in the *Journal of Economic Entomology* (Vol. 1, No. 5), contends that the citrus white fly of Florida is in reality two species, basing his contentions on—(1) 'The presence of a delicate net, consisting of hexagonal meshes, covering the eggs of white-fly in certain localities, while the eggs from other localities were perfectly smooth and glossy. . . . (2) 'Differences in the number of marginal spines of the first stage larvae of the two species have also been noted, together with differences in the size of these larvae.' (3) 'Careful comparisons of the larvae of the first stage revealed the fact that the larva hatched from the reticulated egg develops a waxy border between the marginal spines about as broad as the length of the shorter spines, whereas the larva hatched from the smooth egg develops no such border.' He concludes that, as the species with the reticulated egg is not *A. aurantii*, Mask., *A. marlatti*, Quain., *A. spinifera*, Quain., nor *A. howardi*, Quain., it is probably a new species, unless it is some hitherto little-known species described as occurring on other plants than *Citrus*.

2. *Aleyrodes floccosa*, Maskell.

(*a*) Larva.—Shape elongated elliptical; dorsum very slightly convex. Colour dull-yellow, covered with more or less of white flocculent matter. The tubes of the margin end in minute crenulations, and bear a white, waxy fringe. Dorsum with four pairs of strong spines; one pair on the cephalic, one pair on thoracic, one pair on the anterior abdominal regions, and one pair near the vasiform orifice; the latter is cylindrical and the three other pairs lanceolate. Length $\frac{1}{65}$ inch (0·38 mm.).

(*b*) Pupa-case.—Shape elliptical, dorsum slightly convex. Colour dull-yellow, the enclosed pupa brownish. Margin composed of adjacent tubes, forming conspicuous crenulations

which bear, in addition to the flocculent matter, a moderately long fringe of straight, white, waxy tubes. Dorsum with three pairs of long, slender spines; one pair on the thoracic region, one pair near the abdominal extremity, and one pair near the vasiforum orifice: all the spines are cylindrical with tubercular bases. The larval exuviae are attached to the pupal dorsum by the two thoracic long spines. Vasiform orifice twice as broad as long, anterior edge concave, posterior edge nearly straight, sides rounded. Operculum short, broad, sub-elliptical.

(*c*) Adult.—Unknown.

Habitat.—Barbados, Jamaica, Mexico.

Food plant.—Lignum-vitae.

3. *Aleyrodes floridensis*, Quaintance. (Plate I, figs. 1, 2.)

(*a*) Pupa-case.—Pale lemon-yellow in colour with red spots. There is no marginal or lateral fringe arising from the lateral pores. On the outer margin of the dorsum there is an entire row of conical papillae, from which arise long, slightly curved, glassy, waxen rods. The papillae are set so closely that they touch at their bases. The fringe is divided into rays, each ray consisting of three to eight rods. Margin of case crenulate. Abdomen distinct. The dorsum is marked with radially arranged thickenings, with two rows of coloured pustular spots, which are more distinct in the abdominal region, and with four pairs of minute tubercled setae—one pair at the vasiform orifice, and one pair within the caudal margin. Vasiform orifice cordate, the caudal extremity of which is bluntly rounded and having a minute indenture. Operculum broadly cordate, about three-fourths as long as the orifice, and minutely setose distally. Lingula moderately stout, spatulate, setose distally, with three small lobes on each side and with a large terminal one. Rudimentary feet indistinct on the ventral surface. Length 0·83 mm.; width 0·57 mm.

(*b*) Adult.—Unknown.

Habitat.—Barbados, Florida.

Food plants.—*Psidium Guajava*, Avocado pear, *Smilax*, *Theobroma cacao*.

4. *Aleyrodes goyabae*, Goldi.*

(*a*) Larva.—Colour light-green; size 1·2 mm.; shape roundish, broadest slightly in front of middle. Edge with double fringe projecting continuously outwards in fine indentations, breadth of fringe and greatest cross-measurement as 5 is to 57. Contours of head wedge-shaped, converging forward. Eyes small black. Abdomen with 5 chitin-like bristles, which, however, remain small and soft and never become longer than one-third breadth of body.

*The descripition of this species became available only after Mr. Gowdey had departed from Barbados. The account of *A. goyabae* is taken from a copy of the original description, and inserted where Mr. Gowdey intended it should appear.—Ed. *W.I.B.*

(*b*) Pupa.—With 10-12 radiating long white wax thread forming a star-like pattern. These threads cover the pupa and are seen under the microscope to be grooved longitudinally.

(*c*) Adult.—Female.—Antennae six-jointed, the last three appearing to be a single joint, owing to the fact that the lacings connecting them are only feebly indicated; joint 3 at least three times as long as joint 2; joints 3-6 faintly cross-channelled. Thorax and abdomen broadly joined. The females like to sit on the underside of very young leaves and form a nest-like protecting ring around the eggs which have been laid.

(*d*) Male.—Joints 3-6 of antennae about twice as thick as those in female. Sound organ present. Abdomen, slender, spindle-shaped, not broader than thorax; wings with three systems of shade dots.

Habitat.—Rio de Janeiro, Barbados, Europe.

Food plants.—*Laurus persia*, *Persea gratissima*, *Psidium Guajava.*

5. *Aleyrodes horridus*, Hempel.

(*a*) Pupa-case. Shape elliptical, flat. Colour light yellow. Dorsal surface is covered with white secretion, arranged in a median longitudinal row, and submarginal lateral rows. Around the margin there is also a short fringe of white wax. These details are obscured by a mass of long, yellowish, hair-like secretion enveloping each individual. When denuded of wax the margin is found to be doubly crenulated, with the posterior end of the body rounded, and the anterior end forming an obtuse angle. Dorsum is slightly wrinkled, with a short, median, longitudinal ridge, extending from the anterior end to nearly the middle of the body. Operculum hemispherical, nearly fitting the orifice, the free end notched. On each side of the orifice there is a long seta; two on the caudal end of the body, and two on the ventral surface of the body just cephalad the middle. Antennae and legs are not present. Length 1 mm.

(*b*) Adult.—Female—Colour yellow; eyes black. Wings transparent, yellowish, and thickly covered with a white powder. Antennae seven-jointed; joints three to seven slender, cylindrical; joint two, large, club-shaped. Legs long and slender, nearly reaching to the apex of the wings.

Habitat.—Barbados, Brazil.

Food plant.—*Psidium Guajava*, *Ipomoea battatus*.

6. *Aleyrodes howardi*, Quaintance. (Plate I, figs. 3, 4.)

(*a*) Egg.—Colour uniform brownish. Shape curved. Surface smooth, without reticulations. Stalk short, eggs lying prostrate Size 0·18 x 0·09 mm.

(*b*) Pupa-case.—Shape subelliptical. Cephalo-lateral margin indented, with cephalic end obtusely pointed. Colour, yellowish brown or blackish, when secretion is removed. There is a distinct complete marginal rim with distinct wax tubes,

Numerous wax threads arise from a short rim of wax from the margin of the case. The case is completely hidden by a very copious secretion of grayish, curling wax rods. When this secretion is removed the pupa-case is seen to be at first almost flat, but it becomes convex and segmented as the insect develops. The dorsum with a pair of strong setae on the first abdominal segment, a pair at vasiform orifice, and a pair at caudal margin extending some distance beyond the margin of the case. Vasiform orifice relatively small, sub-cordate the rim dark-brown with six to eight spines, the distal margin with two faint notches; lingula not distinct. Length 0·09 mm. width 0·55 mm.

(*c*) Adult.—Female.—Body yellow, wings immaculate· Length of body 0·84 mm.; forewing 1 mm. long by 0·36 mm. wide; hind tarsus 0·16 mm., hind tibae 0·35 mm.

Male.—Unknown.

Habitat.—Cuba, Barbados.

Food plant.—*Citrus aurantium.*

The pupa-cases of this species were found on the same leaf as those of *Aleyrodes horridus*, Hempel.

7. *Aleyrodes vaporariorum*, Westwood. (Plate II, figs. 1, 2.)

(*a*) Pupa.—The shape of the pupa is usually oval or elliptical. The dorsum is rugose, somewhat convex. There are three pairs of marginal spines; the first pair on the cephalic margin is minute; the caudal pair arises a little inside the margin and is about one-tenth the length of the body, and curves upward and backward. There are three pairs of dorsal spines; the first two pairs are minute but the third pair is usually well developed. The vasiform orifice is triangular with rounded corners and with its apex indented. The operculum is nearly semi-elliptical in outline. Lingula with one large apical lobe and three pairs of smaller lateral lobes, densely covered with longitudinal rows of minute setae. The dorsal wax secretion consists of a double, sub-marginal series of glassy, waxen rods, and a more dorsal series of from five to eighteen rods. On the ventral surface. the antennae, mouth parts, and legs are indistinctly visible. No eyes are distinguishable, but as maturity proceeds the imaginal eyes appear as two reddish spots in the cephalic region. The colour of the pupae is usually greenish-white, with yellow bodies present in the first abdominal segment. The empty pupa cases are white. Length 0·76 mm.; width 0·49 mm.

(*b*) Adult.—Female.- Colour of the head and thorax is pale, yellowish-buff, of the abdomen pale lemon-yellow. Tip of the rostrum is black. Antennae and legs pale yellowish. Vasiform orifice and ovipositor dark-coloured. Head transverse, with a single unpigmented ocellus and two pairs of reddish eyes. Antennae with seven segments. Mentum with four free segments and a basal immovable portion. Thorax short, compact, well rounded above. Fore coxae are slightly longer than middle coxae; trochanters short; femora about two-thirds as long as tibiae. All three pairs of legs are profusely spined. Wings about the same length as the body. Both wings have

a single median vein, that of the posterior wing being nearly straight, and that of the anterior wing being bent toward the posterior margin of the wing at a point slightly beyond the middle. On the margin of the wings there are 'beads,' each bead' consisting of a globule, from the outer side of which arise two or three setae. On the costal margin near the base of the hind wing are three or four slender spines. Abdomen is spindle-shaped and consists of eight segments. The first segment is small, transversed and restricted ; the eighth segment is large and terminated by a short conical ovipositor which consists of three pieces and is surmounted by eight hairs. Vasiform orifice is sub-circular in outline. Operculum sub-quadrate, caudal margin being concave. Lingula extends caudad beyond the vasiform orifice. Length 1·14 mm.

Male.—The male differs from the female as follows: The number of abdominal segments is nine. Vasiform orifice and genitalia are located on the ninth segment. Genitalia forcipate, consisting of two claspers and a penis ; the former being provided with hairs. Length 0·95 mm.

Habitat.—New Jersey, Illinois, Massachusetts, Connecticut, Pennsylvania, Indiana, Mexico, Brazil, Barbados, Europe.

Food plants.—*Gonolobus*, *Tecoma*, *Begonia*, *Aphelandra*, *Salvia splendens*, *Labana commara*, *Fuschia*, *Oxalis*, melon, cucumber, lettuce, *Coleus*, chrysanthemum, heliotrope, bean, egg-plant, *Primula*, tobacco, violet, tomato.

8. *Aleyrodes variabilis*, Quaintance. (Plate I, figs. 5, 6.)

(*a*) Egg.—Colour when newly laid is whitish, but on becoming older it changes to yellowish. Shape, oblong, tapering towards apex, which is bluntly rounded. Pedicel is attached to the centre at the base, bearing several short, irregular prongs. Length—0·2 mm.

(*b*) Larva.—Colour light yellowish. Shape elliptical. No marginal fringe, pores, or papillae. There is a pair of brownish-coloured setae arising from the caudal margin and extending dorso-caudad. Length—0·5 mm.; width 0·3 mm.

(*c*) Pupa-case.—Small, yellowish, mottled with orange empty case clear white. Mature pupa-case convex. No marginal fringe. Margin of case crenulated. Abdominal segments moderately distinct. There are four pairs of brown setae near dorsi-meson : the caudal pair is well developed ; the first pair situated on the thorax, is unusually reduced ; the second pair on the second abdominal segment is often reduced ; the third pair is near the vasiform orifice with a seta on each side near its cephalic margin. Usually the sub-marginal row of papillae and pores is not discernible. Vasiform orifice large, ovate, broad and cephalad. Operculum semi-elliptical. Lingula well developed, the basal part with thickened, centrally curving margins. There are two sets of crescent-shaped thickenings just cephalad of the orifice. A shallow furrow extends caudad from orifice to the margin of the pupa-case. On the ventral surface the legs are barely discernible.

(*d*) Adult.—Female.—Colour lemon-yellow ; antennae and legs pale yellow. Eyes brownish-black, oblong, constricted near

middle. Wings immaculate; anterior margins of both pairs reddish. Antennae seven-jointed, first joint short, sub-conical, distally obliquely truncate; second joint pyriform; third joint, slender, equal in length to the remaining joints; seventh joint, fusiform. Posterior femur and tarsus two-thirds length of tibia. Trochanters with two long setae on caudal side. Mentum three-jointed. Vasiform orifice sub-circular. Operculum convex, but concave on caudal margin, which is minutely setose. Lingula protruding, minutely setose. A basal veinlet arises from the base of the wing, extending obliquely backwards to the margin. Margins of both wings delicately beaded all round. Length 0·83 mm.

Male.—Genitalia forcipate, the valves strongly curved at the tip; penis tapering, short, one-half the length of the valves curved upwards.

Habitat.—Barbados, Florida.

Food plant.—*Carica papaya.*

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The accompanying illustrations are published here as likely to be of interest in connexion with Mr. Gowdey's paper.

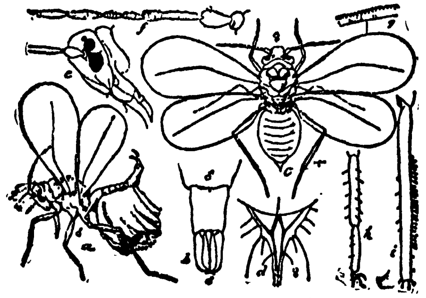

FIG. 1. White fly (*Aleyrodes citri*): *a*, winged male insect, with enlarged view of terminal segments at *b*; *c*, dorsal view of winged female, with enlargements of ovipositor, head, antenna, wing margin, and leg at *d*, *e*, *f*, *g*, *h*, *i* (reduced from Riley and Howard).

From *Year Book*, 1900, U. S. Department of Agriculture, p. 284, fig. 32.

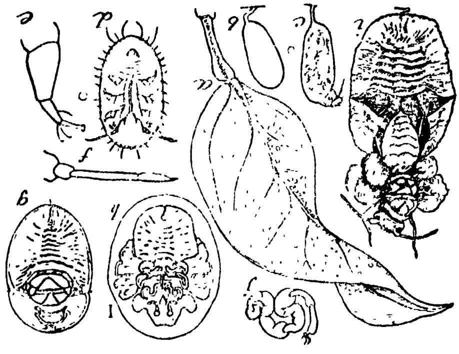

FIG. 12. White fly (*Aleyrodes citri*) : *a*, orange leaf, showing infestation on under surface—natural size; *b*, egg; *c*, same, with young insect emerging; *d*, larval insect; *e*, foot of same; *f*, larval antennae; *g*, scale-like pupa; *h*, pupa about to disclose adult insect; *i*, insect escaping from pupal shell; *j*, leg of newly emerged insect, not yet straightened and hardened—all figures except *a* greatly enlarged. (Re-engraved from Riley and Howard.)

From *Year Book*, 1900, U. S. Department of Agriculture, p. 283, fig. 31.

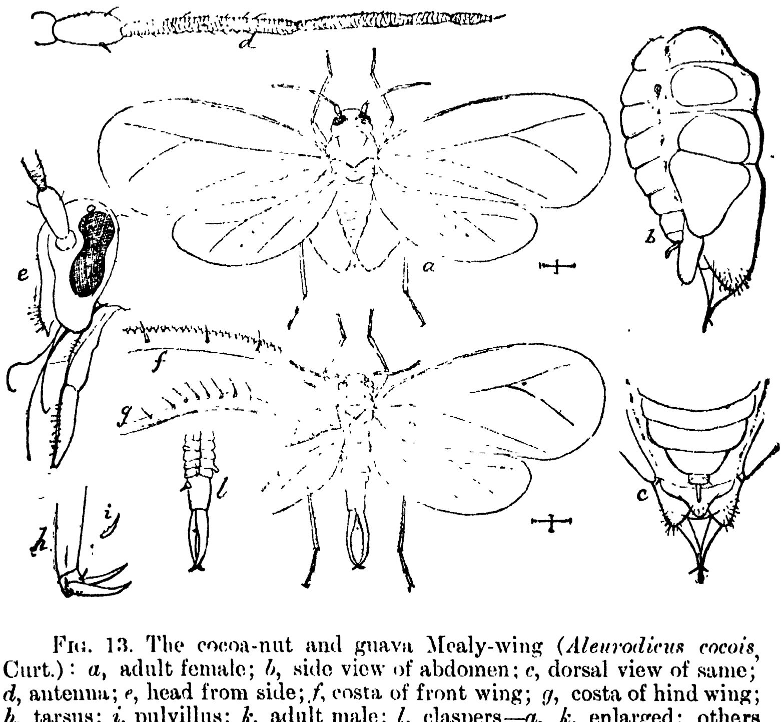

FIG. 13. The cocoa-nut and guava Mealy-wing (*Aleurodicus cocois*, Curt.) : *a*, adult female; *b*, side view of abdomen; *c*, dorsal view of same; *d*, antenna; *e*, head from side; *f*, costa of front wing; *g*, costa of hind wing; *h*, tarsus; *i*, pulvillus; *k*, adult male; *l*, claspers—*a*, *k*, enlarged; others still more enlarged. (Riley & Howard.)

From '*Insect Life*,' (U. S. Department of Agriculture) Vol. V, p. 314, fig. 41.

FUNGUS DISEASES OF COCOA-NUTS IN THE WEST INDIES.

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The fungus diseases of cocoa-nuts have attracted considerable attention during the past few years, and careful investigations have been made. In the *West Indian Bulletin*, Vol. VI, pp. 307-21, a collection of literature available to that date on the diseases of cocoa-nuts in the West Indies was published for the information of those interested.

The bud-rot disease of the cocoa-nut has been investigated in Jamaica and Cuba, and had been reported from Trinidad and British Guiana. A visit was made to Trinidad in 1906 to investigate the diseases of cocoa-nuts. Twenty-nine estates besides numerous peasant properties were inspected, and trees receiving different kinds of cultivation, growing under varying conditions of soil and climate, were examined. Practically the whole of the cocoa-nut area of Trinidad was covered, and several fungus diseases were carefully investigated. Three distinct diseases were found, two due to attacks of fungi, and one of bacterical origin, similiar to the bud-rot disease in Cuba. Specimens of diseased cocoa-nuts have also been carefully examined from British Guiana, and preliminary reports have been made, while in 1908 a cursory examination was made of some diseased cocoa-nut material at the sixth West Indian Agricultural Conference held at Jamaica.

Diseases of cocoa-nuts have also recently received attention in Java, Ceylon, and India. This paper will deal with the diseases of cocoa-nuts investigated in Trinidad, being a summary of the general preliminary report submitted to the Government of that colony. This report was published in the *Official Gazette* and has been reprinted in pamphlet form by the Agricultural Society.

Three diseases that have been found to occur in the West Indies are:—

1. ROOT-DISEASE investigated in Trinidad and from specimens received from British Guiana. Possibly this also occurs in some parts of Jamaica, and a similiar disease has been described by the Imperial Mycologist for India in Travancore.

2. LEAF-DISEASE was investigated in Trinidad and is apparently very similiar to a disease reported from Java.

3. BUD-ROT was found to occur in a few cases in Trinidad, and is also, doubtless, to be found in British Guiana, Jamaica, and Cuba. It is now under careful investigation in Cuba, where it has occasioned wide-spread damage.

ROOT-DISEASE.

An attack of this disease is generally first shown by the leaves. They show a slightly wilted appearance, then turn yellow, first at the tips and then gradually all over the leaflets. These dry up, blacken, hang down from the 'cabbage,' and often remain for a considerable time before they are shed—a badly attacked palm often being entirely enclosed in numbers of leaves around its trunk. Frequently, however, it is noticed that the leaves do not hang down around the trunk, but the petioles break across, leaving the sheathing portion on the trunk while the foliage portions of the leaves have fallen to the ground. Sometimes the petiole does not completely break, and the foliage portion of the leaf hangs vertically downwards attached to the portion of the petiole that is left attached to the stem.

The outer leaves are sometimes those that show signs of wilting and yellowing first, but this is not always so, for frequently palms may be noticed in which a 'middle' ring of leaves becomes wilted and yellow, while rings of green leaves remain above and below.

After the yellowing of the leaves, trees bearing a good crop of nuts, as a rule gradually shed most if not all of them, irrespective of their size and stage of development, and the flowers subsequently produced do not set. In fact, it is possible for a person to pick out with certainty, trees that are diseased before any yellowing of the leaves is noticed, by carefully looking at the condition of the leaves and at the latest flowers that are being put forward. Any trees that are diseased can at once be singled out. The local conditions of the soil must be considered before a tree is definitely stated to be diseased, as the whole appearance of the diseased trees suggests a lack of water, and, therefore, may be confused with trees that are suffering from this cause alone in drought-affected areas.

After a number of the leaves have yellowed and died, it is only a question of time before the terminal bud becomes a putrid mass,* and falls over, and the palm eventually dies.

SEQUENCE OF EVENTS IN THE DISEASE.

Trees which only present external signs of disease to the experienced observer show that apparently the roots are probably the parts which become first affected. After a considerable number of these have been rendered useless in contributing to the life of the plant, changes take place which result in a sour-smelling, red discoloration in the stem that probably commences at the level of the ground and extends upwards.

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* When a cocoa-nut palm is affected by any disease or pest, the terminal bud, in the advanced stages of the disease almost invariably becomes involved in a rot. This must not be confused with the bud-rot disease. This appears to be a specific disease, and the roots, stem, and leaves are sound, while the bud is in a diseased condition.

The position of this red discoloration would appear to vary in the stem directly with the roots that are affected, and it has been repeatedly noticed that when a 'middle' ring of leaves shows signs of yellowing, the discoloration is found towards the centre, while if the lowest leaves become wilted, the stem presents a ring of discoloration towards the outside of the stem. The petioles also show that they are infested with the mycelium of a fungus, for when the leaves become dry and hang down, the fructifications push through the epidermis and form pustules of varying size and shape. Eventually, when the vitality of the tree has been reduced, the terminal bud, as already mentioned, becomes infested with a 'rot,' which causes the whole 'cabbage' to fall over, resulting in the death of the tree.

MICROSCOPIC EXAMINATION.

Specimens of leaves, roots, stems, petioles, etc., were taken from a considerable number of diseased trees for examination, and for cultural and infection experiments.

In a diseased root, the walls of the cortex cells appear to be shrunken and the cells are turgid no longer. Between the walls of consecutive cells can be seen large, dark-coloured, septate hyphae, while many of the cells themselves have become invaded by the same. When a cortical cell is threatened by the approach of a fungal hypha, its cell contents appear to become altered, for large yellowish globules make their appearance. Whether these have been produced by the cell itself as a means of protection against the fungus, was not definitely determined, but after the mycelium has gained an entrance into the cell, these globules, as well as all the other cell contents are destroyed and absorbed.

The fungus spreads from one cell to another by piercing through the cell walls, and soon obtains an entrance into the thin-walled cells of the xylem parenchyma, and eventually into the xylem vessels themselves.

The red discoloration of the stem was carefully examined microscopically, but, except in the case of trees that were very badly diseased, few fungal hyphae could be detected. Those observed in the advanced cases of disease were similar to those noted in the roots, but it is most probable that the red discoloration of the stem is primarily due to the disorganization of normal functions through the stoppage of supplies from the roots.

It was observed also that, almost without exception, the petioles of the leaves of badly diseased trees showed a large number of minute ruptures of the epidermis, after they had died and had fallen to the ground. The petioles in varying stages of disease were therefore submitted to a careful microscopic examination, and it was observed that a mycelium of a fungus was found in all diseased petioles.

The point of the first attack could not be determined, but that part of the petiole just where it expands to ensheath the stem of the tree, is the part where the effect of the fungus is first noticed. The whole petiole gradually assumes

a blackish colour, the leaflets become brown, and eventually on the dead petioles, fructifications burst through the epidermis just where it begins to expand before ensheathing the stem. These pycnidia give off a black, powdery dust which consists of the spores of the fungus. These are of two kinds—the one single-celled and colourless, and the other two-celled and brown.

DETERMINATION OF FUNGUS.

The two-celled spores suggested that the fungus belonged to the genus *Botryodiplodia*, and specimens were forwarded to Dr. N. Patouillard, for identification. He reported as follows:—

'I have examined the specimens of parasitic fungi on petioles of cocoa-nut.

'The epidermis is raised and split but covers the fungus. Out of the slit, a black powder, which is formed of brown, uniseptate spores protrudes. If a section is made through the wart-like pustules, there is found under the skin a black cellular stroma filled with several pockets. These spaces are filled with colourless, non-septate spores. If these are placed in a damp chamber, in about twenty-four to thirty-six hours, germination takes place. The colourless spores are therefore adult and mature. If we consider the fungus in respect to its hyaline spores, it must be considered a *Cystospora*, or better a *Fusicocum*.

'If the brown, septate spores really belong to it and are the final end of the development, the fungus will be a *Botryodiplodia*. It remains then to establish that these last belong to the fungus. It is very probable but not proved.'

In working out the life-history of the fungus it has been frequently observed that the colourless spores become brownish in colour and afterwards septate. Considering that no difference can be noted in the mycelia produced by the two fungi, that the pycnidia bear both kinds of spores, and that the colourless cells have been observed to divide by a single septum and then become brown, it may be concluded that the septate, brown spores are the final production, and that the fungus must be considered as a species of *Botryodiplodia*.

EFFECT OF FUNGUS.

The damage caused by the fungus in the roots by the disorganization of the cortex and other cells has been observed, and therefore the effect this has on the cocoa-nut plant may clearly be understood. A reduction in the water-absorbing power of the root system takes place, and less fcod substances are elaborated.

Young trees do not appear to suffer to any considerable extent, for numerous instances have been noticed of young plants having quite a healthy appearance while a number of the roots were in a diseased condition. When, however, the fruiting period comes on, a large drain is made upon the tree. It is taxed very highly and, if the roots are diseased, wilting

and yellowing of the leaves are noticed. · It was observed that trees that were just coming into bearing were the most liable to succumb.

GENERAL OPINIONS AS TO THE CAUSE OF THE DISEASE, ETC.

The general opinion of the planters of cocoa-nuts was that this disease is due to the weakness of the plants produced by the setting of immature nuts. In some districts, histories of weather-beaten cargoes of green nuts having been driven on the shores and the nuts used for planting purposes were held out as the cause of the trouble. This disease, however, was not limited to a few scattered trees, and evidence distinctly points to its being infectious. A tree that has become attacked by the disease is sooner or later surrounded by a large number of others showing signs of the disease. In one portion of the Cedros district, the disease has been noticed making its way gradually into other fields of cocoa-nuts farther south. It is, therefore, impossible to believe that the large areas of cocoa-nuts in Cocorite, Laventille, Guapo, Cedros, and the interlands of Mayaro were planted with immature nuts.

Moreover, the fungus found in the roots and in the petioles of diseased trees is capable of attacking vigorous trees. Anything that tends to reduce their vitality would considerably help along the fungus. Circumstances which retard growth, both of the root and shoot system give the root fungus a much better chance. This was conspicuously brought to my notice on a portion of an estate in the Cedros district. A low-lying hollow showed that a large quantity of water was present in the soil. Such a condition was unfavourable to good development of the trees; they were stunted in growth and showed that root development was not very large. The clayey, impervious nature of the soil suggested that an elaborate system of drainage was needed in order to procure the aeration necessary for vigorous plant growth. In this hollow, most of the trees had died out very rapidly and the disease had soon spread from this portion of the estate to other parts where the soil conditions were more favourable. Trees on sandy soil on higher ridges were often noticed to be attacked, but it was generally in low-lying, undrained hollows that the disease was the worst. This is also seen in the Guapo and Mayaro districts.

These examples should suffice to show how natural peculiarities of an estate and other physical features affect the disease. But these alone cannot be sufficient to cause the death of the trees, as is often urged. The characters of the soil affect the growth of the plant and they may also affect the fungus, and, therefore, it is necessary to keep the condition of the soil as good as possible, in order that it may be favourable to the growth of the plant.

The death of the trees in some districts appeared to be very rapid. Three or four months is generally the time that intervenes between the first external symptoms and the death of the tree, and usually within another three months a ring of diseased trees is noticed around the dead stump. In another district, the disease is much less prevalent and the death of

diseased trees does not take place so rapidly, for in places where two trees are growing from the same hole, the death of the second usually takes place from nine to twelve months after the death of the first.

NATURAL INFECTION AND SPREAD OF THE DISEASE.

Samples of soil from around the roots of diseased trees have been investigated microscopically, and sterile mycelium was found. This would suggest that the mycelium is capable of spreading through the soil. This mycelium may be capable of attacking and killing the youngest rootlets and then entering into the larger ones. The entry of the mycelium into the roots is still an unsolved problem, but evidence tends to show that the larger roots first show signs of infection where the smaller rootlets join them. In no case has the mycelium been noticed on the exterior of the roots, and it would seem that it has to depend upon the rot of the smaller roots for its distribution.

The roots of several young supplies that were planted upon or near to the place where diseased trees have been removed, showed on examination, the presence of a mycelium within them, but not in sufficient quantities to cause their death. This indicates that infection can take place through mycelium. Infection experiments have been conducted in the laboratory of the Imperial Department of Agriculture, and in the field in Trinidad, which show that the fungus is parasitic in habit and can attack healthy cocoa-nut tissue.

It would appear to be probable that the disease may spread:—

(1) By mycelium through the soil from root to root.
(2) By spores blown from tree to tree.
(3) By germinating tubes of spores from petioles, attacking either the roots of the same tree or the roots of another.
(4) By germinating 'chlamydospores' from decaying petioles.

The best conditions for the germination of the spores depend upon the presence of suitable quantities of air and moisture, and spread of the disease would be expected to be the most rapid when the conditions are favourable.

The spread of mycelium in the soil depends a good deal upon the cultivation. Any condition of the soil that is unfavourable to the cocoa-nut may favour the root disease by hindering free root development. Excessive moisture and excessive drought may be favouring conditions for the disease. The latter cannot be remedied except by irrigation, and does not appear to be a factor of any importance in this disease. The former—excessive moisture—is noticeable in many of the low-lying portions of the estates. In these hollows, the soil is often of a clayey nature—impervious to water—and, therefore, many of the air spaces between the soil particles are replaced by water. The normal working and growth of the roots are interfered with and the destruction of such roots by fungal

mycelium may speedily follow. The effects of excessive moisture can be lessened by careful attention to drainage, and to the mechanical condition of the soil.

REMEDIAL MEASURES.

Although the complete life-history of the fungus and its method of spread are not yet known with certainty, it would appear that owing to its habit of penetrating and spreading in the living tissues of the root of the host plant, cure is practically outside the question when a large majority of the roots are permeated with mycelium. Therefore it is probable that only the most drastic measures are likely to provide permanent relief.

It cannot be expected that the disease can be entirely eradicated; but, by a method of what is known as 'stamping out,' the amount of disease may materially be reduced and the fungus kept in check.

There are six principal ways in which we may hope to attack this disease. These are:—

(1) Destruction of all diseased material.
(2) Isolation of diseased areas.
(3) Resting of infected land before planting 'supplies.'
(4) Spraying and application of chemicals.
(5) Improved cultivation and drainage.
(6) Searching for and propagating disease-resistant varieties.

Destruction of all Diseased Material.

It has been observed that diseased petioles that have fallen to the ground often bear large numbers of spores. This would indicate that the fungus in the petioles is capable of living upon dead matter, i.e., is saprophytic during some stages of its life-history. Young supplies, planted on the place whence dead trees have been removed have also been noticed to be affected, and old stumps that have been left standing have become permeated with fungal mycelium. These instances show that there is sufficient food in the form of decaying vegetable matter in old trees, etc., to continue the life of the fungus and, therefore, all dead or diseased material in an infected area should be entirely destroyed and not left to accumulate.

(*a*) All dead and dying trees should be cut down, and burnt whenever that is possible. When the trees contain a large amount of sap and still bear a fair number of green leaves, it is almost impossible to burn them, unless a number are collected and burnt in a pit after the manner of 'charcoal fires.' Otherwise these trees should be cut up and buried deeply with lime. The adoption of the burning method would probably prove to be the most effective, but experience will show whether it is the most practical.

(*b*) All diseased leaves and petioles that have fallen to the ground should be collected and immediately burned on the spot.

(*c*) On no account should rubbish, such as husks, etc., be allowed to accumulate in any infected area, for this may prove beneficial to the growth of the fungus, which may continue to live on it, and thus it would form a base from which the disease can spread to living trees.

(*d*) The basal portion of the diseased trees and as many diseased roots as possible should be destroyed. It may be expensive to 'grub up' these stumps, but when it is borne in mind that the fungus can live in the old roots and is liable to attack young supplies, as well as probably to spread through the soil to healthy trees, such a destruction is necessary. An old East Indian cocoa-nut authority* holds that a large number of the roots of a cocoa-nut tree may be destroyed by cutting the tree near to the ground, leaving the stump for some time to dry, and then building a heap of trash and forming a fire (preferably closed by putting a thin layer of soil on the top) over the remains of the stump. In this way, he states, most of the roots will be destroyed, for once the fire has obtained a good hold it will travel for some distance down the roots.

There is also another danger of leaving old trees and rubbish about the plantation,—they offer sufficient food for beetles, etc., which may increase rapidly and become a source of danger.

It is necessary that all cultivators of cocoa-nuts should combine and have all diseased material destroyed, for it is useless for any planter to keep his estate clear of all disease while his neighbour neglects trees which become a permanent source of infection. Only the most energetic action is likely to prove beneficial, for it has been observed that there is a marked tendency for the disease to spread from certain centres of infection.

Isolation of Diseased Areas.

The disease generally appears, at first, in small patches, while the surrounding trees are apparently unaffected. As the mycelium of the fungus may spread through the soil, these diseased areas may be isolated by cutting trenches from 1 foot to 18 inches deep around them. It must be remembered that the mycelium may have spread further than is noticeable on the trees and, therefore, the trench must be made to include several trees that are apparently healthy, and care should be taken to throw the excavated soil into the diseased portion and

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* All about the 'Cocoa-nut Palm,' Ferguson, Ceylon, p. lxxxiii. We have no experimental evidence of the value of this suggestion in practice, but it might be given a trial in the dry season when the weather conditions are favourable.

not outside it. Such a method of isolation, especially where the diseased areas are small, cannot be too highly commended in dealing with root diseases; but the amount of success depends entirely on the thoroughness with which the work is carried out. In any case it may prove to be a very good method of confining the disease to a limited area.

Resting of Infected Land before Planting Supplies.

Young supplies that have been planted in infected land have shown that they have been attacked by the fungus, and therefore it would appear necessary to rest such land for a series of years after the removal of diseased material before commencing to replant. In this way it is hoped that the fungus mycelium may be starved out. At the same time it affords an opportunity for careful cultivation of the land. Such land should be turned up, either with the plough or with the fork, so that the fungus mycelium may be turned up and exposed to the destructive action of the sun, and when supplies are put in they should not be planted in the old rows, but rather between them, so that the new plants alternate in chess-board fashion with the spots whence diseased trees have been taken.

The careful cultivation of the land before replanting should improve the condition of the soil, and possibly green dressings of leguminous plants might be profitably grown and ploughed in. Some of the soils are already rich in organic matter, and here some remunerative rotation crops might be grown on badly infected lands for a year or two before planting the young supplies.

Spraying and Application of Chemicals.

When diseased trees are cut down and destroyed there may be fungal mycelium left in the soil. As pointed out previously, a good deal of this can be destroyed by exposure to the action of the sun; but it can also be destroyed, to a large extent, by the use of lime. The lime should be, if possible, unslaked, as in this state its fungicidal powers are far greater than when it is slaked. It should be applied before forking or ploughing, and the amount to be used must depend upon local conditions, and upon the extent of the disease. The fungicidal powers of good lime have not yet been sufficiently realized, and besides, there is improvement of the condition of the soil on account of clay flocculation, and of the fertility of the soil on account of the rendering available of dormant plant food.

A method of preventing death of forest trees, etc., from root diseases in France is to lay bare the base of the trunk and as many roots as possible, and to apply quantities of sulphur or ferrous sulphate.

The spraying of diseased trees with Bordeaux mixture may also prove beneficial in destroying spores of the fungus on the petioles, and applications to surrounding trees might prevent them from becoming infected by spores blown by the wind.

Improved Cultivation and Drainage.

It has been noticed that the disease is the more destructive in undrained land. Stagnant water should not be allowed to remain in the soil, as this tends to hinder healthy root development and also favours the spread of the fungus. It would appear that water may be present at the roots of the cocoa-nut to almost any extent, but the necessary condition is that it should not be stationary. Proper drainage not only relieves the soil of excess of water, but also allows greater root development to take place, and thus secures the plant against effects of drought.

The cultivation of land under cocoa-nuts is, as a rule, neglected, and instances have been noticed where old plantations have been giving smaller yields of nuts, that have been gradually diminishing in size, year after year. Better cultivation and drainage would offer more favourable opportunities for the cocoa-nut, and would be of considerable value in dealing with the root disease, especially in wet areas with soil of a clayey nature. It would afford a better chance for the plant to make use of plant food, either from the soil or from manures. (The evidence of a planter in the Cedros district, which shows returns of 120,000 nuts per year from an area that gave 40,000 nuts per year five years previously through judicious applications of manures, emphasizes the fact that the cocoa-nut readily responds, in some soils at least, to liberal applications of manures.) It also would be expected that the condition of the trees would be considerably improved. By encouraging healthy growth and increasing the vigour of the trees, they will be able better to withstand the attack of the fungus.

Searching for, and Propagating, Disease-resistant Varieties.

A good deal of work has been done in combating plant diseases by selection of disease-resistant varieties, and therefore it may be a matter of the greatest importance to make further observations in this direction, as the selection of a resistant race of cocoa-nuts may prove of the utmost importance in combating this disease. During my visits through the different parts of the island, I made careful observations and inquiries in this direction, but I am unable to say with confidence whether any varieties of cocoa-nuts are disease-resistant. Several planters state that a variety known as the 'Green Spanish' is very hardy and is able to withstand attacks much longer than other varieties. From personal observation in the badly diseased districts it would appear as if all varieties are attacked, but, if every cocoa-nut planter would note the comparative resistance of the various varieties, considerable advance in this direction might soon be made.

In conclusion, it should be stated that in cases where the fungus has completely devastated large areas, the trees should not be allowed to stand and rot, for these would only be nurseries for the development and spread of the disease, and seeing that such varying conditions of soil and climate, etc., exist in the cocoa-nut districts, it is not supposed that all the remedial

measures suggested will be applicable to every plantation. Therefore it must be left to the planters themselves to choose those which they, from local experience, think to be the most applicable to their own particular conditions. The destruction of all diseased material on systematic lines, however, should be practised by all, for it is expected that by such co-operation the injury would soon be mitigated to a large extent, and the disease kept well in hand.

RESULTS OF REMEDIAL MEASURES.

Reports have periodically been received from those areas of Trinidad where this disease is most prevalent. Several of the large planters have co-operated in a systematic adoption of the remedial measures above given, with the greatest success. On the larger properties the disease is now said to be well under control, and it is hoped that the smaller proprietors also will adopt similiar measures. Destruction of all diseased material and an improved system of drainage and cultivation have apparently successfully checked the spread of the disease.

LEAF DISEASE.

GENERAL CHARACTERS OF THE DISEASE.

Many trees are noticed which have leaves that appear to be drooping, and with the tips of the distal leaflets of a greyish colour. An external examination of the leaflet shows that whereas the tip is quite dry and dead and that many parts of the edges of the leaflet are in a similar condition, there are small yellowish spots, more or less regular in shape, which may be observed to increase in area (spreading centrifugally from a point in a more or less circular manner), scattered about the leaflet. These areas may be observed to increase gradually in size, and not infrequently to run into one another, forming irregular blotches, which often eventually cover the greater portion of the surface of the leaflet.

During the growth of the spots, they gradually change from a yellowish colour to a greyish white, and each is bordered by a margin which is of a dark colour, generally an intense greenish-brown. At first, therefore, it is easy to recognize the various 'diseased spots,' for in each the oldest part is always in the centre, and proceeding outwards from this, each successive ring has been more lately attacked than the last. This can be seen by the fact that the centres of the spots always become grey first, while rings of yellow of varying degrees of intensity can be noticed outwards from this grey centre.

By careful observation it will be noticed that the discoloration more often appears on the under side of the leaflet first, but the pale yellow, and later the greyish discoloured areas, are equally evident on both surfaces. This is due to the disappearance of the chlorophyll, and the subsequent death of the cells comprising the tissue of the leaflet, as the diseased areas are generally sunken through, being thinner than the healthy portions.

It would appear that the tips of the distal leaflets show the effects of the disease first, although an examination of an affected leaflet shows that diseased areas are scattered all over its surface. From these distal leaflets, the disease appears to spread gradually to those nearer the stem, and often when all the leaflets on the terminal 2-3 feet of the leaf have been attacked, and appear in a dry, withered condition, this portion of the leaf breaks down, if the leaf happens to be floating in the air in a position between the vertically upright and the horizontal. This end of the leaflet rarely falls to the ground, but remains hanging to the healthier portion, and is very characteristic of the disease.

If, however, the leaf is older before it is attacked, i.e., hanging between the horizontal and the trunk of the tree, the tip does not often break. This shows that the breaking of the tips of the leaves is due to the weight of the diseased portion itself, and is, therefore, due to natural causes. Many trees were examined that showed leaves with their tips broken off and hanging down in this manner, and all showed that they had disease spots distributed throughout their leaflets.

The yellowish spots that are characteristic of the disease in such cases are found in the greatest abundance on the distal leaflets, but eventually all the leaflets become attacked.

After a time, when a large number of disease spots have made their appearance, the whole leaf assumes a yellowish appearance and gradually becomes greyish and withered. This may remain hanging to the trunk for a considerable time, but finally it drops. In the early stages of the disease, only a single leaf may be attacked, but usually several are noticed on every diseased tree. As a result of the diseased condition of the leaves, the number of nuts borne on the later-developed flower-stalks diminishes, and finally no flowers set. When a large number of leaves have been badly attacked, the terminal bud is left standing alone, and it is only a question of time before this falls over, and the death of the palm results.

Close examination of the upper surface of the leaf of one of the disease spots when it has assumed the grey colour shows minute pustules. They are blackish-grey in colour, and are irregularly distributed, often being very numerous. They are more or less oval in shape and suggest that the upper cuticle of the leaf has been raised. This can be shown to be so, for if a diseased leaf that has fallen on the ground where sufficient moisture is present, be examined, it will be observed that these small pustules rupture, usually by a triangular slit through which the greyish spores protrude.

MICROSCOPIC EXAMINATION.

Specimens of leaves, roots, stem, etc. were taken from diseased trees for microcospic examination and, whereas the roots and stem appeared to be quite normal, the leaves were in a diseased condition. By cutting a transverse section through a diseased spot while still yellow, there could be noticed, by careful staining, a delicate, septate, branched

mycelium, occupying the intercullar spaces and running between the cells. These eventually become pushed apart from one another by the invasion of this mycelium from which minute branch-like structures are sent off into the cells themselves. They may possibly act as *haustoria* or sucking organs. Finally these branches appear to grow, and eventually the cells and vessels of the leaf become invaded with mycelium which probably causes the death of the invaded patches. The margin of the diseased spot is characterized by a ring of dark colour, and examination shows that here the mycelium of the fungus is only intercellular, and that the filaments end in this dark margin. This may mean that the leaf is responding to the unnatural irritation caused by the invasion of the fungus, and is probably secreting some substance with which to protect itself.

When the diseased spot becomes grey and dry, the minute pustules on their upper surfaces begin to make their appearance. These small pustules bear the spores of the fungus.

INFECTION EXPERIMENTS.

The infection experiments leave no doubt that this leaf fungus may be weakly parasitic, and show that infection can take place by the germination of the spores, the germinal tubes of which can pass through the stomata of the leaf, and through wounds of any kind on the leaf surface. No result, however, was obtained when the spores were placed on the upper surface of an uninjured leaf, which may indicate that these germinal tubes are incapable of penetrating through the epidermis of the leaf.

DETERMINATION OF FUNGUS.

Recently, a report on a disease of cocoa-nuts caused by *Pestalozzia Palmarum*, Cke., by Dr. Charles Bernard, has come to hand from Java. Differences occur in the description of the disease from Cuba (*West Indian Bulletin*, Vol. VI, p. 313) and that from Java. In Cuba, the fruiting bodies of the fungus are described as being emitted from the under surfaces of the leaves, whereas in Java the fructifications occur on the upper surface only. The distribution of the disease in Java appears to be limited to young plants, and seems to do the most damage when the young plants are beginning to take root in the ground, after they have exhausted most of the stored material from the endosperm of the seed.

Despite certain differences in the appearance and size of the spores of the fungus found in Trinidad and that described from Java, the germination of the spores appears to be similar, and many symptoms of the disease in Trinidad are identical with those described in Java.

I am of the opinion that the Trinidad and Java fungi are merely geographical varieties of *Pestalozzia Palmarum*, Cke., and not distinct species.

NATURAL INFECTION, ETC.

During the short time that was given to the investigations of this disease, evidence could not be obtained on the time it takes from first infection by germination of a spore to the production of a yellow spot on the leaf, nor on the time it takes for spores to be produced; but the following information on this point has been obtained during the work of Bernard on a similar disease in Java:—

> 'Two very vigorous cocoa-nut trees, situated near a diseased plantation were isolated, and in the crown of one was placed a bunch of badly diseased leaves. After two months (this is the period of time that is generally considered to be the "period of incubation" of the disease, i.e., the time which intervenes between the moment that infection takes place and that when the first exterior manifestations of the disease appear) this tree showed the characteristic spots upon its leaves, spots which grew and caused three months later (i.e. five months after infection) the death of the tree. The adjoining tree, which was not infected, remained healthy and vigorous.'

There can therefore be no doubt as to the cause of the disease or to the ease with which it can spread, for this parasite, as seen by the above experiment, is the primary cause of the disease, and is not a secondary appearance on plants in bad condition.

It would appear however, that the leaf, after succumbing to the numerous drains upon its resources, falls to the ground before the mycelium has obtained the possible limit of its development; for if a leaf that has fallen into a dry place be placed in a moist chamber, a multitude of pustules bearing conidia will be produced within forty-eight hours, while if a leaf that has fallen in a damp place, where it is shaded from the effects of the sun, be examined, large numbers of spores can be seen to be given off, thus showing that the mycelium is capable of further growth after the leaflet has fallen to the ground.

EARLY OPINIONS AS TO THE CAUSE OF THE DISEASE.

Evidence on the cause of the disease was gathered from planters of cocoa-nuts, but, as in the root diseases, the general opinion was that it was due to the weakness of the plants, produced by setting immature nuts, or to improper soil conditions. It is impossible to believe that a large portion of an estate in the Mayaro district or isolated patches in the Icacos district would be planted by immature nuts alone, for the disease does not appear upon a single tree here and there. As to improper soil conditions, it is generally held that favourable conditions of soil are necessary for the growth of strong, vigorous, healthy plants, and therefore every effort should be made on the part of the planter to understand the different soil conditions of his estate, and to assist nature whenever

possible. This is the most perplexing question with which the planter has to contend, requiring judgement that can be gained only by many years of practical experience.

From experiments previously mentioned there can be no doubt as to the fungoid nature of the disease, and measures for combating its ravages will be considered later. The spread of the disease certainly appears to be influenced by the age and condition of the plants, and therefore improved cultural methods are of paramount importance.

EFFECTS OF FUNGUS IN THE PLANT.

The primary damage done by this fungus has been seen to be the destruction of the cells of the internal tissues of the leaflets. This destruction continues if the conditions are favourable for the fungus, and gradually the leaf-area of the plant is reduced. Under extremely favourable conditions, many of the leaves become entirely destroyed, through the mycelium from a large number of disease-spots spreading throughout the whole of the interior of the leaf. When this happens, the whole of the leaf-area of the plant is destroyed, the terminal bud falls over, and the tree eventually dies.

At other times, large numbers of disease spots are scattered about the leaves, but not in sufficient quantities to cause the death of the plant. These spots, however, have been rendered, through the destruction of the chlorophyll of the leaf, useless to the plant, and, therefore, the plant becomes gradually weakened.

To the planter, the most important of the checks is that given to flower development. Less flowers are produced, and finallv the diseased condition of the trees becomes marked in the shortness of the crop of nuts. Again, food is cut off from the development of nuts, their size diminishes, and their saleable value becomes reduced.

It has been noticed that in some instances the shortage of crop, etc. can be traced directly back to the damage done by the leaf-fungus. In some cases where the 'disease-spots' are few in number, little damage was noticed, nor do they seem to increase until the conditions become unfavourable to healthy growth of the host plant.

It would appear, therefore, that this fungus is a weak parasite, and is only capable of doing appreciable damage when the conditions are extremely favourable for its development.

The fungus that is present on cocoa-nuts in Java is also a weak parasite, and there the damage seems to be limited to young plants just after being planted out, when they are sending out roots in search of food for themselves after having used up all the stored material of the endosperm of the seed. Therefore, if the conditions are such as to promote healthy, vigorous growth in the cocao-nuts, the fungus may be overcome and its attack, for a time at least, thrown off.

REMEDIAL MEASURES.

A consideration of the life-history of the fungus and the relation between it and the cocoa-nut suggests the remedial measures likely to be effective in dealing with the disease. The measures suggested can only aim at the reduction of the amount of the disease and at keeping the fungus well in check, for it would be impossible to suggest treatment that will entirely eradicate it. The remedial measures must be divided under two heads :—

(1) Those which will destroy or weaken the fungus, and

(2) Those which encourage a more vigorous growth of the cocoa-nut, so as to enable it better to withstand any attacks of the fungus.

(1) The spores of the fungus, under favourable conditions, exist in such numbers that unless these are destroyed it is possible for the disease, given warm and moist, or windy weather, to spread very rapidly :—

(*a*) All dead trees should therefore be cut down, all the portions carefully collected on the spot where the tree once stood, and the whole *burnt*. Great care should be exercised in collecting the portions of diseased plants, and the burning should be done in the diseased area of the field, for if diseased leaves are carried or dragged about the field, there is much danger of spreading the disease. Although it is only the leaves and petioles that are diseased, it would be wise to burn as much of the tree as possible in order to prevent decaying stumps being left about the plantation to become infected with other diseases and pests.

(*b*) Trees that are showing a few diseased leaves should be climbed, and the diseased leaves cut down and burned. The manager of the estate of Icacos has burned several trees that have shown signs of disease, by sending a boy up the tree, packing dry material in the lower leaf-sheath bases and setting fire to the whole. This method, in some instances, has given good results, for all the lower diseased leaves and all the fungus spores were destroyed. Considerable damage, however, is often done to the tree by this method, and at least two or three crops of nuts are destroyed. It would probably be just as effective to cut down the diseased leaves and burn them on the ground, for in this way damage by burning would not be done to the young parts at the terminal bud.

(*c*) It would be advisable to search through the plantation to see whether any isolated trees show the characteristic broken-tips of the leaves with the pustules on them, and if such are found, these trees should be marked on the stem with a suitable mark so that they can be carefully watched, as they may possibly be the source of infection for another area. All leaves showing signs of disease should be destroyed

with fire, and such trees should be examined at least once every fortnight until no further spread of the disease is observed. These trees should be carefully attended to, manure should be given them and the soil around them properly tilled, in order to enable them to throw off the attacks of the fungus.

(*d*) If the disease continues to spread, spraying with fungicides would render the spores of the fungus incapable of germination, and would therefore be effective in keeping the disease in check. The fungus is most easily assailed through those portions of it that come to the surface--the spores, for their germination can effectively be prevented by the use of chemicals: but the problem remaining to be solved is how frequently is it necessary to apply such an external remedy. Without further information such a question cannot be answered, but continued observation would soon reveal an answer to this important question. How soon after complete destruction of the spores will a fresh batch be produced on the same leaf? This is the question to be answered, and such an answer must be a guide to the frequency of the use of fungicidal spraying.

Bordeaux mixture would probably be the fungicide that would be used most economically, and spraying with this would need a spray pump, and a long hose attached to the pump. The nozzle may be tied to the end of a long bamboo, or a boy may be sent with it up the tree in order that the highest trees could be sprayed. All trees showing any signs of disease and any in their immediate neighbourhood should be sprayed at frequent intervals, and thus most of the spores would be prevented from germinating

(2) It has been noticed that this disease, at present, is doing serious damage only when the conditions of the soil and cultivation are unfavourable to healthy plant growth, and, therefore, in order to keep the cocoa-nut palms in vigorous growth, such points as drainage, manuring and cultivation should be carefully attended to. In the interlands of the Mayaro district, which are low-lying and often water-logged, the conditions could easily be improved by a system of drainage. The soil there is of a clayey nature, and is somewhat impervious—not soil the most suitable to sucessful cocoa-nut cultivation. Some of the land is below the sea-level and, therefore, it is impossible to obtain an outflow for the surplus water; but much of the surface water and that in the top 6 or 9 inches of the soil might easily be removed by the digging of a system of wide drains about 18 inches deep. Even draining such a portion of the soil would prove beneficial to the cocoa-nut trees, as they feed mainly by roots in the top layers of the scil and therefore the removal of an accumulated mass of 'sour' water should prove to be an incentive to further root formation.

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Moreover, here, as on the estate in Icacos district, where the diseased areas appear to be on the light dry soils, the

question of manuring and cultivation of the soil should be carefuly attended to. Manures must not be looked upon as a means of curing disease, but they may be the means of strengthening the growth of the plant, and the problem of manuring should be solved by the best resources at the command of the estates.

A SECOND FUNGUS IN THE LEAF DISEASE.

When diseased leaflets have become dry, and when the wart-like pustules of *Pestalozzia* have made their appearance, there can frequently be noticed (besides the grayish-black pustules of *Pestalozzia*) small, round spots that are quite black. These black spots appear to follow the veins of the leaflet and are usually to be seen in the greatest numbers on the lower surface of the leaflet near the mid rib. They are also frequently seen on the lower surface of the leaflet and the flower spathes and, some times, the petioles are covered with black spots, the individuals of which are just visible to the unaided eye, but as a whole, often appear as a blackish incrustation.

On the leaflets where the black spots are seen, the greyish colour noticeable in the case of the *Pestalozzia* is marked by a dark-brown colouration in the case of this second fungus. This appears to be due to dark-coloured mycelium in the dried-up tissues of the leaflets. In no case has the presence of this second fungus been observed on leaflets that had not been previously attacked by *Pestalozzia*. It would, therefore, be concluded that this second fungus is only of secondary importance. Infection experiments, etc., would tend to show that it can attack leaflets that have previously been weakened by attacks of *Pestalozzia*, but until further experiments have been conducted, it is impossible to say whether it is a direct parasite or not.

IDENTIFICATION OF FUNGUS.

The fungus must be referred to the *Fungi Imperfecti*, and on account of the character of the pycnidia and the spores, it must be referred to *Macrophoma* if the unicellular spores are considered mature and final, or to *Diplodia* if the two-celled brown spores are the final results of development.

It is possible that this fungus may be similar to that lately described by Emerson from Bowden, Jamaica, and is identical in the *Macrophoma* form with *Sphaeropsis palmarum*, Cooke, from petioles and mid ribs of cocoa-nut from Demerara, and in the *Diplodia* form with *Diplodia epicocis*, Cooke, from dead young leaves of cocoa-nut.

DISTRIBUTION AND REMEDIAL MEASURES.

This fungus has been found in Icacos, Cocorite, and the Mayaro districts, and seems to be closely associated with the leaf disease and, therefore, until further experiments can be conducted to inquire into its exact habit, the remedial measures suggested for the leaf disease should be sufficient to keep it in

check. Whenever it should be noticed without the *Pestalozzia* of the leaf disease, similar remedial measures should be employed and should undoubtedly prove beneficial in preventing its spread.

It is hoped that before long further information can be given about the habit of this fungus, and then more definite recommendations can be made.

BUD-ROT DISEASE.

In having trees felled that were showing signs of the root disease in the Cedros district, a tree was sometimes found which did not show the symptoms characteristic of the root trouble. The roots appeared to be healthy, the stem showed no signs of red discoloration, while the bud was involved in a vile smelling sort of bacterial rot. It was reported that about 1 per cent. of the diseased trees in this district showed signs of a bud trouble, but that they were seldom met with except as isolated cases. On visiting a small savannah planted in cocoa-nuts in the Siparia district, it was noticed that the trees were in a diseased condition. The youngest leaves appear to stand upright and do not unfold as they should. Afterwards, they turn yellow and then brown in colour, and the whole appearance is that of a withering tree with the centre of the cabbage in an unhealthy condition. Sometimes this dying of the 'central bud' could not be noticed until many of the lower leaves had turned yellow or brown, nor did there appear to be any regular succession of deaths of the lower leaves, for often the lowest leaves were the first to turn yellow, while at other times the 'middle' leaves showed the first signs of being unhealthy.

After a time the terminal bud falls over, frequently leaving a ring of quite healthy-looking leaves at the top of a 'headless' trunk.

On cutting down several of these trees, it was noticed that while the roots and stem were perfectly healthy, the bases of the youngest leaves and their wrappings were in a rotten condition, as were also the bases of the still unfolded flower stalks. This rot, in a diseased palm that is still standing, is invisible until the harder outer coverings of the bud are removed and it is found to be limited to the softer tissues. Instead of finding a healthy white cabbage, a pale-brown, rotten mass is seen. It extends in badly diseased trees from the bases of the youngest leaves for a distance of 3 or 4 feet downwards until it reaches the harder tissues of the stem. Sometimes it spreads in thinnish lines, which can often be noticed externally by the leaves of one side of the tree turning yellow, while the others are apparently healthy, but at other times it seems to spread centrally, and the varying external symptoms must be accounted for by the assumption that the rot has no set method of spreading, and, therefore, whatever leaf has its food supplies cut off first must show the first signs of withering and yellowing.

A badly diseased bud is generally full of fly larvae, etc., and the smell is awful. It resembles closely the bud of a tree badly attacked with root or leaf disease and, therefore, suggests

that further researches are greatly needed before any definite conclusion about its origin can be arrived at.

Microscopic examination of the roots and stem indicated that they were quite normal, while those portions of the terminal bud, in the advancing margin of the disease, showed in most cases bacteria of different kinds, but in two instances the advancing margin was marked by a reddish discoloration produced by some fungal mycelium. Although this mycelium has been more or less successfully isolated, fruiting bodies have not been obtained nor have the few infection experiments given positive results. Of the bacteria, two have been isolated in pure cultures, while at least one more has been observed in a rotten bud. Two of the bacteria are apparently gas-producers and have been found in rotten terminal buds of trees that have suffered from the leaf disease or the root trouble, while another has only been noticed in rotten buds from the Siparia district.

Whenever the youngest visible leaf is observed to be lopped over and wilting, the terminal bud is sure to be involved in a soft rot. The roots and stem appear to be quite healthy and no evidence of damage to the tree could be found.

The few isolated cases in the Cedros district would indicate that this disease is not of a very infectious character, but large numbers of trees have been killed out in the Siparia district, the spread of the disease being very rapid and apparently from the windward. I am inclined to the view that this disease is similar to the destructive disease of cocoa-nuts in Cuba; but, as far as Trinidad plantations are at present concerned, it would appear to be largely due to unfavourable conditions of soil, drainage, etc.

Weakly trees, whether caused by bad drainage, inferior cultivation or inferior soil are the most likely to be those that are attacked by disease, and therefore improved conditions of cultivation, etc., should render the trees more capable of withstanding attacks.

REMEDIES.

More prolonged study and much experimental work are necessary to demonstrate conclusively the cause of the disease. With our present knowledge of the nature of the disease it is impossible to suggest a remedy for trees that are already infected, and, therefore, steps must be taken for preventing its spread.

The rapidity with which the trees have been killed in the Siparia district, and the marked resemblance of this disease to that which has proved such a menace to the cocoa-nut industry of Cuba, should illustrate the need for vigorous action being taken in order to prevent further spread of the disease.

All diseased trees showing only the 'bud-rot' should be cut down and destroyed. If the planter is sure that it is only bud-rot and not root disease (which is characterized by the disorganized condition of the cortex of the roots, and by the reddish ring of discoloration in the stem) it should be sufficient to cut off the top 4 or 5 feet from the diseased trees

and bury deeply with lime (it would be found impossible to burn such rotten masses as diseased buds). The remainder of the trunk and all rubbish should also be collected and burned, or otherwise these may serve to harbour other pests, which eventually may become destructive. The felling and destroying of diseased trees is undoubtedly an expensive process, but the neglect of these precautions may make all the difference between a trifling loss of trees and a serious epidemic

It is also necessary that united action should be taken, for it is useless for one planter to care for his estate and destroy all diseased material while his neighbours allow the disease to multiply and their estates to become centres of infection.

From observations made in the Siparia district, it would appear that any variety of cocoa-nut tree may be attacked, but it would be advisable to look diligently for plants that are resistant to this disease, for the selection of the most hardy varieties may be a means of assisting better cultivation, destruction of all diseased material, etc., in dealing with this disease.

MILLIONS AND MOSQUITOS.

BY H. A. BALLOU, M.Sc.,

Entomologist on the staff of the Imperial Department of Agriculture for the West Indies.

In Barbados, there are to be found in the streams and ponds great numbers of a very small fish. The common name of this fish is 'Millions,' and it probably refers to the enormous numbers in which they occur.

This fish has been identified by Mr. G. A. Boulenger, F.R.S., of the British Museum, as *Girardinus poeciloides*, De Filippi; and, in reply to a query from the Imperial Department of Agriculture, Mr. Boulenger stated that *G. versicolor*, Gunther, is probably a synonym, but that further material from the original locality (San Domingo) would be required to settle the question.

Millions are found in all the natural surface streams and ponds of Barbados. Their extremely small size (1-1½ inches in length) enables them to penetrate into very shallow water, and they may be seen even among the grass roots along the borders where the water has a depth of scarcely ¼ inch. In the rainy season they often travel from the permanent water into small pools, which are only temporary in their nature. They are strong swimmers for their size, and can make headway against a considerable current.

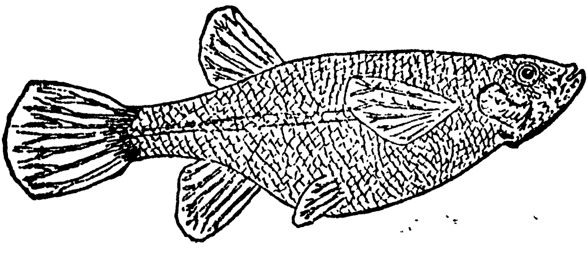

FIG. 14. *Girardinus poeciloides*. About twice natural size. (Drawn by C. W. Jemmott.)

As already mentioned, millions are very small in size. A full-grown female may measure 1½ inches in length, but this would be only in the case of the largest. The male is much smaller, rarely exceeding 1 inch in length. The newly born young are so small as to be difficult to distinguish even in an aquarium jar. It is next to impossible to see them in the waters of their natural habitat. The adult female is dull in

colour without conspicuous markings; the adult male is much brighter, with a conspicuous black eye-spot and bright red splashes on each side.

The species are viviparous, i.e., there is no deposit of eggs or spawn, but the young are brought forth as active, swimming fish. This must be of advantage to the species, for although the number of young born in this way is probably smaller than the number of eggs that would be produced, it seems likely that the percentage to reach maturity must be much greater. At any rate, they multiply with great rapidity under favourable conditions, and the water they inhabit is often fairly alive with the swarms of these tiny beings.

Millions belong to the Cyprinodontidae or top-minnows, which are mostly small, carnivorous fish which feed and swim near the surface. The lower jaw is rather elongated and the top of the head flattened. This structure facilitates the surface feeding.

There are many species of top-minnows, known in both North and South America. *Girardinus versicolor*, described from San Domingo has already been mentioned. Recently (December 1908) specimens of a small fish very similar to the Barbados millions have been forwarded from St. Lucia, which is believed to be indigenous to that island. This may prove to be the same or a nearly related species.

Jordan (*Manual of Vertebrates of Northern United States*, 1884) states that one species of the family Cyprinodontidae, (*Girardinus formosus*) from South Carolina and Florida, 'is said to be the smallest known vertebrate.'

Attention has been attracted to millions in Barbados on account of the habit of these fish of feeding on the immature stages of mosquitos. The theory has been advanced that it is because of this habit and the numbers of the fish, that Barbados is free from malaria. It has often been stated in newspaper articles and in letters received by the Imperial Department of Agriculture, that in Barbados the millions feed on the larvae of the malarial mosquito. This is not quite correct, because the malarial mosquito does not breed in Barbados. It is well known that the millions do, however, feed on mosquitos, and in fact any water in which these fish are fairly numerous is always free, or nearly free, from mosquitos. They feed on mosquito eggs, larvae and pupae, and probably on many other forms of aquatic life. They are perhaps the most energetic natural enemies of mosquitos in Barbados, and they are very useful for stocking tanks, fountains, etc., etc., to prevent the breeding of mosquitos. Millions adapt themselves easily to life in captivity and they thrive well in the situations just mentioned.

When well fed, these fish do not appear to be ravenous feeders, but when they have been deprived of food for several days they are most voracious. A very small fish will attack a large full-grown mosquito larva, and failing to capture it at the first attempt, will follow it up by repeated trials until success attends its efforts. This has been observed in an aquarium jar, where it has also been noted that even when

gorged to distention, the hungry millions will continue to make frantic efforts to catch more and more of these larvae, until they are unable to swallow the latest capture. A fish holding a large mosquito larva in its mouth until some of the food already swallowed can be digested, is not an unusual sight. The captured larva, it will be observed, is gradually swallowed, as room is made to receive it.

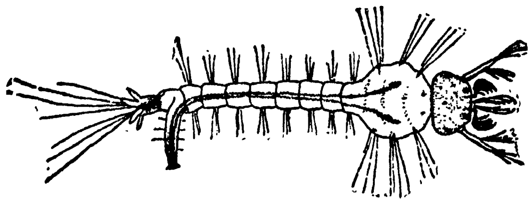

FIG. 15. Larva of Mosquito. *Culex pungens.* From U.S. Department of Agriculture, Bureau of Entomology, Bulletin No. 25.

As an experiment, a garden tub was made ready for aquatic plants, and some ten days elapsed after the tub was filled before millions were put into it. During this time, the water became literally alive with mosquitos. It was feared that the few millions which were put into the water would not be able to destroy all the mosquitos before they should have time to finish their development. Accordingly a small quantity of kerosene was thrown on the surface of the water in order to kill off the large number of mosquitos, and thus leave to the millions merely the task of keeping the water free from any fresh invasion. During the first week after the introduction of millions into this tub a few mosquito larvae were to be seen in the water, but during the next six months none were seen although the water was carefully examined for them from time to time.

In another instance, a number of millions were kept in a jar in the laboratory of the Imperial Department of Agriculture. They had been several days without food, when a collection of living mosquito larvae was brought in from a stagnant roadside pool. As these larvae were introduced into the aquarium they were attacked vigorously and persistently by the fish, which fed until gorged.

The most abundant mosquitos in Barbados are the yellow Fever mosquito, *Stegomyia fasciata*, and the filarial mosquito *Culex fatigans*. The species of *Anopheles* which are responsible for the dissemination of malaria are not known here.

The life-history of a mosquito includes the four distinct stages of development common to most insects, viz: egg, larva, pupa, and imago or adult.

The immature stages of development of mosquitos are passed in water. The eggs are laid on the surface, either singly or in masses. The larvae hatched from these eggs are the

water worms or wrigglers which are familar to every one. The pupa is, like the larva, a wriggler in the water, but is slightly

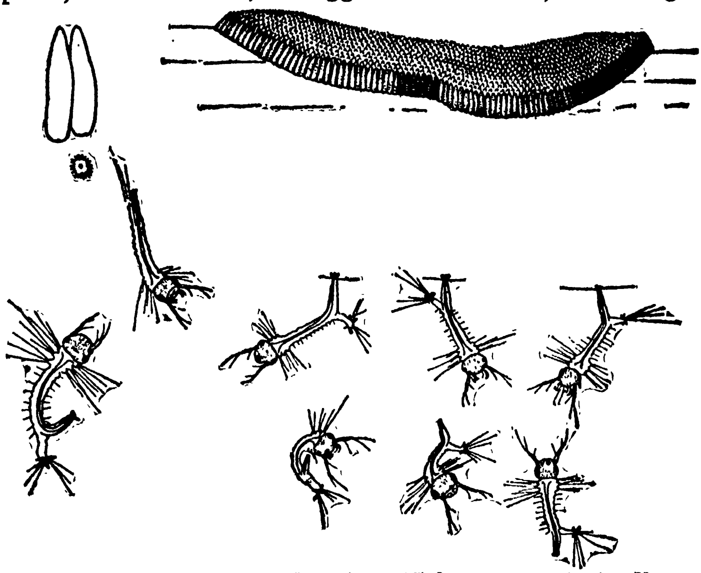

FIG. 16. Eggs and larvae of Mosquito. (*Culex pungens.*) (*a*) Egg mass. (*b*) Eggs from mass more highly magnified. (*c*) Larvae or wrigglers. From U.S. Department of Agriculture, Bureau of Entomology, Bulletin No. 25.

changed in appearance as a result of the developing wings, antennae, and legs, which characterize the adult or winged form, which we know as the gnat or mosquito.

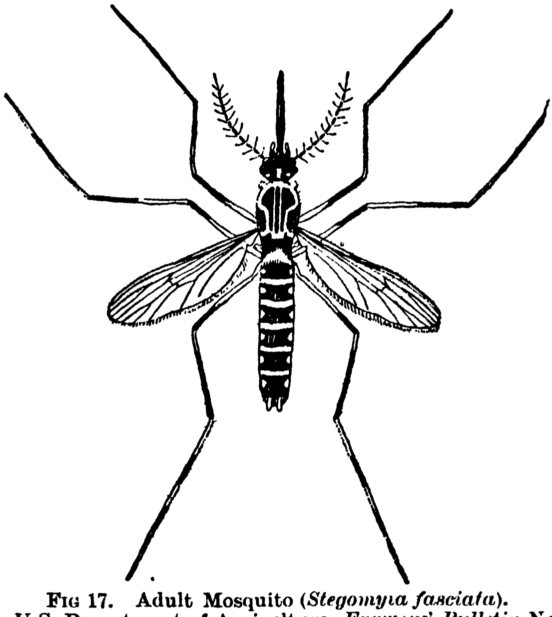

FIG 17. Adult Mosquito (*Stegomyia fasciata*).
From U.S. Department of Agriculture, *Farmers' Bulletin* No. 155.

Mosquitos breed with great rapidity. Not only do the females produce a large number of eggs, but the time required for the development from egg to adult is very short.

The breeding places of mosquitos are many and diverse, the one requisite being water; slow-moving or standing water. There seem to be specific or generic differences in the breeding places of mosquitos; that is to say, while certain genera or species of mosquito may choose a variety of breeding places, others confine themselves to one kind. For instance, there is in Barbados a mosquito which breeds in the water in the holes of the land crab, and is believed not to breed anywhere else. *Culex* and *Stegomyia*, however, breed in a great variety of places. Any standing water such as might be found in rain-water barrels, fountains, tanks, old tins, bottles, and receptacles of that sort, and roadside pools, swamps, or the borders of sluggish streams, will often be found swarming with mosquito larvae, which may be either *Stegomyia* or *Culex* or both. It is likely also that they breed in the water held by the sheathing bases of the leaves of many plants, but though I have searched for them in these places in Barbados I have not found them.

The *Anopheles* mosquitos, however, are reported to breed only in fairly permanent, natural pools at or near the ground level.

Dr. L. O. Howard, in a paper entitled 'Notes on the mosquitos of the United States' (*Bull.* 25, Bur. Ent., U.S. Dept. of Agric.), states that 'Ross found in India, that while the species of *Culex* generally bred in vessels of water around the houses, the species of the genus *Anopheles* bred in small pools of water on the ground. This point was made the subject of a special investigation by the expedition of the Liverpool School of Tropical Medicine to Sierra Leone. While *Culex* larvae were to be seen in almost every vessel of water or empty gourd or flower pot in which a little rain-water had collected, in only one case were *Anopheles* larvae found in such receptacles. On the other hand, they occurred in about 100 small puddles scattered throughout the city of Freetown—puddles mostly of a fairly permanent description, kept filled by the rain, and not liable to washing out during heavy showers. It was noticed also that the larvae seemed chiefly to feed on green water weed.

'In the interesting and important paper by Dr. J. W. W. Stephens and Mr. S. R. Christophers, entitled "The distribution of *Anopheles* in Sierra Leone," published in the report of the Malarial Committee of the Royal Society, July 6, 1900, it is stated that 'at Freetown not only do the larvae of *Anopheles* exist in the small pools in the rocks, but also in the pools by the sides of streams and in certain small drains, and that in the dry season, in the absence of the rock pools, *Anopheles* breeds freely in streams and drains: also, in the dry season, the adults exist in most parts of the town in dwellings, especially in overcrowded native huts and native quarters, ready to lay their eggs when pools appear. It is interesting to note from this latter observation, that the authors of the paper recommend the destruction of dirty huts, and the prevention of excessive

overcrowding. Outside of the city, in the "bush," *Anopheles* larvae were present throughout the whole district. In the mountain streams, wherever there were suitable pools, multitudes of larvae existed. In tracing the mountain streams occasionally for half a mile or so, they found no larvae, but then a rock pool occurred, and they were again found in numbers. At Songo and Mabang they were able to detect *Anopheles* larvae in the swamps. They were not present in the main swamp water on account of the innumerable small fish, but were occasionally observed in small isolated pools on the mud, and were still more common in small pools at the edges of swamps. It is a noteworthy fact that they did not occur in swamp pools in such numbers as in the streams and rock pools among the hills of Sierra Leone. These rock pools would appear to be the most suitable conditions for the breeding of *Anopheles*.'

Mr. A. H. Kirby (*Agricultural News*, Vol. IV, No. 131) states that in Antigua, '*Anopheles* larvae have only been observed in shaded streams and ponds.'

Major Hodder (Report on the Destruction of Mosquitos, St. Lucia, 1904) states that the *Culex* 'are more or less domesticated and are found in houses and towns as well as in swamps. They breed in gutters, water tanks, and filthy pools in back yards with equal facility. Their larvae can be found in the gutters of high buildings or on the ground level.'

'So far as my observation goes, such is not the case with the *Anopheles*; they do not deposit their eggs anywhere except close to the ground level; I have examined hundreds of tanks 4 or 5 feet above the ground, but in not one single instance have the larvae been found therein, although the tanks were actually standing on ground where these mosquitos lived.

'But although I can see no proof of their breeding in the artificial receptacles provided by man for water supply, there can be no doubt that they come into houses and stay there for a considerable time, their probable object being to obtain blood from the inhabitants; at any rate, that most certainly is what they proceed to do immediately on arrival.'

NATURAL ENEMIES OF MOSQUITOS.

Mosquitos have many natural enemies, of which fish are perhaps the most effective.

Many insects which are aquatic in habit feed on mosquitos either wholly or in part; and mosquitos are attacked by parasitic forms of animal life such as nematode worms and mites.

Dr. Howard (*Mosquitos*, New York, 1902) states: 'By far the most effective natural enemies of mosquito larvae and pupae are fish. Almost all of the small carnivorous fish which inhabit swamp pools and still water will feed upon mosquito larvae. Nearly all of the minnows, especially those forms known as top-minnows, of the genera *Fundulus* and *Gambusia*, feed abundantly upon insects found near the surface of canals, slow streams, mill ponds, and other similar places, and, although not

at all specific in their choice of the early stages of the mosquito, eat them perhaps with even more avidity than any other aquatic insect, especially such as are hard-shelled.'

'Some observations upon the natural enemies of the malarial mosquitos of the genus *Anopheles* have been made by Dr. C. W. Daniels in East Africa ("Reports to the Malaria Committee of the Royal Society," December 31, 1900). He says that fish, and especially young fry and small fishes, will speedily destroy the mosquito larvae, but in spite of this, *Anopheles* larvae are often found in pools, rivers, etc., where fish are abundant, and pupae and mature larvae among them. This is seen in open pools as well as in the grass-grown rivers.'

In response to requests from many localities, millions have been forwarded by the Imperial Department of Agriculture to be introduced as natural enemies of mosquitos, and where sufficient time has elapsed since the introduction, good results are reported.

Enquiries have also been received as to the possibility of transporting millions to Southern Nigeria, Cyprus, and Uganda, and as to the probable effect on the prevalence of malaria in those countries. It is likely that the difficulties of the actual transportation would be small, and that there would be good results if the fish were once established, and the reduction of the number of mosquitos would probably have a very noticeable effect on the prevalence of malaria. It would always be advisable to study the habits of any local fish however, before introducing a new species, especially to discover whether the local fish are likely to prove enemies to the introduced species, and also to learn whether they may not be used to good advantage in combating mosquitos by being introduced into bodies of water where they do not naturally occur.

It is hardly to be expected that the introduction of a few insect-eating fish into the waters of any locality will result in the extermination of all the mosquitos or entirely free it of a dread disease such as malaria. There can be no doubt, however, that fish are capable of greatly reducing the mosquito nuisance, and that the prevalence of malaria can be very much lessened in any locality by the judicious use of fish as natural enemies of mosquitos. Much has been written in recent years about mosquito control, and all who are interested in the problem will be aware of the necessity of removing as far as possible the breeding places of mosquitos. After this has been done, the introduction of small carnivorous fish, such as millions, will be likely to have a very appreciable beneficial effect.

Millions were sent from Barbados by the Imperial Department of Agriculture to Antigua, and St. Kitt's-Nevis in 1905, to Jamaica in 1906, and, in 1908, to Guayaquil, St. Vincent, and St. Lucia. The lot sent to Antigua arrived in good condition, and were kept in a tank at the Botanic Station until they had increased sufficiently to be distributed without weakening the supply. The fish were liberated in several ponds and streams, and flourished so well that the Country Board of Health undertook the work of stocking all the ponds and streams

of the island. At the present time, in about three years from the first introduction, all the more or less permanent water of that island is stocked, and planters and others have commented on the apparent abatement of the mosquito nuisance in many localities in that island.

Experiments with millions in captivity showed that they could be fed on a variety of food. They are not strictly insectivorous, but rather general feeders. Of course, living food is preferred, such as mosquito eggs, larvae, and pupae, and other minute forms of aquatic life; but it was found that raw beef or hard-boiled eggs, finely chopped, were eaten greedily, and corn meal and bread crumbs were also eaten but not so readily. Plant lice (Aphidae), the young of scale insects (Coccidae), and red spiders (Arachnidae) have also been eaten by millions in captivity.

From Barbados to Guayaquil is the greatest distance that millions have been sent by the Imperial Department of Agriculture. They were contained in two kerosene tins, in each of which were about 100 fish in about 2 gallons of water. These tins were fixed in boxes large enough to allow a packing of 2 inches of sawdust around the sides and at the bottom of the tin. A piece of wire gauze was fastened on the top of each tin so as to prevent the fish being thrown out if the water was splashed by the rolling of the ship or by carelessness in handling the tins.

Directions were given that the fish while *en route* to Colon should be fed on finely chopped raw beef, finely chopped hard-boiled eggs or corn meal, not more than a teaspoonful to each tin at a time, and that not oftener than once in two days. H. M. Consul at Colon was asked to have the tins cleaned out by siphoning off the sediment at the bottom of the tins and fresh water added to make up the original amount of 2 gallons, and to have the same feeding directions carried out on board ship from Panama to Guayaquil.

The Imperial Commissioner of Agriculture has been notified that these fish reached their destination in good condition. Only one dead fish was found in the tins at Panama and none at Guayquil.

For shorter journeys, the kerosene tin without any outside packing, but with the wire gauze, and a bar of wood for a handle, has been found satisfactory. On these shorter journeys, lasting two or three days, it has not been found necessary to feed the millions. In addition to the consignments of millions sent out by the Imperial Department of Agriculture, many others have been sent to other places by persons resident in Barbados, not connected with the Department.

In 1905, top-minnows *Molliensia latipuma*, *Fundulus grandis*, and *Gambusia affinis*, were introduced from the United States into the Hawaiian Islands, as natural enemies of mosquitos. (Introduction of top-minnows into Hawaii, *Press Bulletin* 20, Hawaii Agricultural Experiment Station.) The work was carried out by an official of the United States Fish Commission who collected the fish in Texas and, after a number of experiments in feeding and keeping them,

accompanied them on the long journey to Honolulu. During the twelve days occupied by the journey, twenty-seven fish died out of a total of 450. It is reported that these fish have multiplied rapidly, and that several hundred thousand have been bred and distributed with good results in the control of mosquitos.

Referring again to the theory already mentioned, that the abundance of millions in the waters of Barbados would account for the fact that malaria and the malarial mosquito have never become established, it might be well to indicate some points that seem to disprove the theory. In the first place, while millions do inhabit the permanent surface waters of the island to such an extent as to make it practically impossible for mosquitos to breed there, many pools which disappear in the dry sesaon, afford opportunities for mosquito breeding during the rainy season sometimes for several months together. Many of these pools are so situated that millions never get into them, and although they are inhabited by great numbers of aquatic insects and tadpoles, they furnish breeding places for mosquitos.

Again, the *Anopheles* mosquito is known to exist in St. Lucia, from which island has just been received the small fish resembling the Barbados millions, already mentioned. Evidently the fish is unable to exterminate the *Anopheles* in St. Lucia.*

Millions cannot be given entire credit for the absence of the *Anopheles* mosquito from Barbados, but they would probably be very influential in keeping the numbers of the mosquito down to a minimum if it should ever gain a foothold, and there can be no doubt that were it not for these fish, the existing species of mosquitos would be much more abundant than they are at present.

* The small fish has been identified as *Girardinus poeciloides*, and is therefore the same species as the Barbados Millions. [ED. *W.I.B.*]

ERRATA.

Page 83, line 25, *for* '£100 per mile' *read* '£800 per mile.'

Page 97, line 8 from bottom: 'plus the weight of *water*' should read 'plus the weight of *juice* in the 26 grammes of megass taken.'

Page 109, line 12 from bottom, *for* 'plays' *read* 'play.'

Page 111, line 10 from bottom, *for* 'Is it' *read* 'It is.'

Page 239, *For* Legend under Fig. 7 *read* 'Eggs and Larvae, (*a*) Eggs and (*b*) Larva of lace-wing fly; (*c*) Larva of lady-bird. All enlarged.'

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